

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB-282 752

Testing Program for Mining Coal in an
Oxygen Free Atmosphere
Volume II - Appendices

Island Creek Coal Co, Holden, W Va Island Creek Div

Prepared for

Industrial Environmental Research Lab, Cincinnati, Ohio

Jun 78

TESTING PROGRAM FOR MINING COAL
IN AN
OXYGEN FREE ATMOSPHERE

Volume II - Appendices

by

R. C. Taliaferro
Island Creek Coal Company
Holden, West Virginia 25625

and

Don Motz
Cyrus Wm. Rice Division, NUS Corporation
Pittsburgh, Pennsylvania 15223

14010 DZM

Project Officer

Donald J. O'Bryan
Industrial and Extractive Processes Division
Office of Research and Development
Washington, D. C. 20460

U. S. ENVIRONMENTAL PROTECTION AGENCY
INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY
CINCINNATI, OHIO 45268

TECHNICAL REPORT DATA		
(Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA-600/7-78-080b	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Testing Program for Mining Coal in an Oxygen Free Atmosphere - Volume II - Appendices	5. REPORT DATE June 1978 issuing date	6. PERFORMING ORGANIZATION CODE
	8. PERFORMING ORGANIZATION REPORT NO.	
7. AUTHOR(S) R. C. Taliaferro, Don Motz	10. PROGRAM ELEMENT NO. 1NE 623 B	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Island Creek Coal Co. Cyrus Wm. Rice Div. Holden, WV 25625 NUS Corp. Pittsburgh, PA 15220	11. CONTRACT/GRANT NO. Grant 14010 DZM - Phase II	
	13. TYPE OF REPORT AND PERIOD COVERED Final	
12. SPONSORING AGENCY NAME AND ADDRESS Industrial Environmental Research Laboratory-Ci Office of Research and Development U.S. Environmental Protection Agency Cincinnati, OH 45268	14. SPONSORING AGENCY CODE EPA-600/12	
	15. SUPPLEMENTARY NOTES	
16. ABSTRACT A systems evaluation was undertaken to demonstrate the ability of miners wearing life support systems to operate conventional mining equipment and to mine coal at a test section in an active ventilated mine. Their ability to operate mining equipment and to perform other in-mine tasks was successfully demonstrated. No major difficulties were encountered in performing these tasks and the miners reported they had never been that comfortable before when working in a mine. The life support system provided cool, clean air for the miner and did not hamper his ability to work. The system was adequate to demonstrate the miner's ability to mine coal while wearing a life support system. However, mechanical failures in the chiller and rebreather module were experienced. Additional work to develop a totally reliable life support system and further testing under ventilated conditions are required before testing in an oxygen-free atmosphere. This volume contains the Appendices only. The main body of the report has been published as a separate volume, available from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161; as EPA-600/7-78-080a.		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Underground Mining Coal Mines Life Support System	Oxygen free mining atmosphere	6K 8I 13K
18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 242
	20. SECURITY CLASS (This page) Unclassified	22. PRICE PCA 11/0 441

DISCLAIMER

This report has been reviewed by the Industrial Environmental Research Laboratory-Cincinnati, U. S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U. S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This volume contains the Appendices of a report which is a systems evaluation of the concept of applying an oxygen-free atmosphere to active deep coal mines. The purpose of the program was to demonstrate that miners wearing life support systems can satisfactorily operate conventional mining equipment and mine coal.

The successful application of this concept could eliminate dust inhalation and fire and explosion hazards, reduce mine drainage, and eliminate the need for rock dusting and the use of special explosion-proof equipment. Where mines produce large quantities of methane gas, capture and sale of the gas would be possible.

This report will provide key information to those interested in the feasibility of mining in an oxygen-free atmosphere or converting an existing mine to oxygen-free operation. For further information contact the Resource Extraction and Handling Division.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

A systems evaluation was undertaken to demonstrate the ability of miners wearing life support systems to operate conventional mining equipment and to mine coal at a test section in an active ventilated mine. Their ability to operate mining equipment and to perform other in-mine tasks was successfully demonstrated. No major difficulties were encountered in comfortable before when working in a mine.

Four life support systems, one conventional section of mining equipment, an office building and a dedicated test face in an active ventilated mine were used in the project. Minimum modification to the mining equipment was required to receive and operate the life support system.

The life support system provided cool, clean air for the miner and did not hamper his ability to work. The system was adequate to demonstrate the miner's ability to mine coal while wearing a life support system. However, mechanical failures in the chiller and rebreather module were experienced. Additional work to develop a totally reliable life support system and further testing under ventilated conditions are required before testing in an oxygen-free atmosphere.

This volume contains the Appendices only. The main body of the report has been published as separate volume, available from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161; as EPA-600/7-78-080a.

This report was submitted in fulfillment of Project No. 14010 DZM - Phase II between the Environmental Protection Agency and Island Creek Coal Company. Also participating in this project was the Cyrus William Rice Division of the NUS Corporation.

CONTENTS

	<u>PAGE</u>
Foreword	iii
Abstract	iv
Figures	vii
Appendices	
A. Training Manual	1
List of Terms	1
Miner's Life Support System	2
Oxygen, Carbon Dioxide, and Carbon Monoxide	24
Operating Instructions	37
Entering the Mine	48
Refuge Station	53
Leaving Mine	56
Shutdown Procedure	56
Servicing the Life Support System	60
B. Operating and Maintenance Manual - MSA	65
General Information	66
Rebreather Module Description	69
Chiller Module Description	77
Electric Schematic	80
Operation	83
Maintenance	95
Trouble Shooting	108
Parts List	110
Spare Parts	114
Brochures	115
C. Operating and Maintenance Manual - Cambion	
Dehumidifier Air Exchanger	126
D. Operating and Maintenance Manual - Emergency	
Rebreather	134
E. Specifications - Miner's Life Support System	138

F. Specifications - Mining Equipment -	
Phase II	152
Roof Drill	152
Shuttle Car	155
Cutting Machine	158
Loading Machine	161
Face Drill	164
Transformer - Rectifier Unit	166
Safety Circuit Center - AC	169
Safety Circuit Center - DC	170
5KV Mine Power Cable	171
High Voltage Cable Couplers	172
High Voltage Gang Operated Load Break Switch	173
G. Specifications - Communications System	174
H. Phase II Office - Design Drawing List	181
I. Phase II Office - Construction Drawing List	183
J. Demonstration Mine - Design Drawing List	185
K. Specifications - Mining Equipment -	
Demonstration Mine	189
Feeder Breaker	189
Underground Belt Conveyor	193
112 1/2 KVA Belt Transformer	202
Operating Personnel Car	204
Supply Units	205
Drag Tank	207
Stacking Conveyor	210
Shuttle Car	212
L. Water Analyses	215
M. Project Delays	222
N. Demonstration Mine Costs	227
O. Suppliers of Communications Systems	233

FIGURES

	<u>PAGE</u>
 Appendix A	
1 Calf and Wrist Seal	6
2 Oxygen Tolerance in Man	27
3 Carbon Dioxide Effects vs. Time	29
4 Carbon Dioxide Effects vs. Concentration	30
5 Carbon Monoxide vs. Exposure Time (1)	35
6 Carbon Monoxide vs. Exposure Time (2)	36
7 Cooling System - Test and Assembly Area	39
8 Tether Hook-Up for Cooling	44
9 Service Record	61
 Appendix B	
1 Flow Schematic for MPRS Unit	68
2 Chiller Flow Schematic	79
3 Electrical Schematic - MPRS Unit	81
4 Tether Connections for MPRS Unit	86
5 Blower Performance Curve	91
6 Carbon Dioxide-Odor Removal Canister Telescopic View	96
 Appendix C	
Wiring Diagram-Dehumidifier Air Exchanger	133

APPENDIX A

TRAINING MANUAL
FOR
MINER'S LIFE SUPPORT SYSTEM

LIST OF TERMS

MLSS - Miner's Life Support System

MPC - Mine Personnel Coverall

MPCC - Mine Personnel Chiller-Condenser

MPCS - Mine Personnel Communication System

MPERB - Mine Personnel Emergency Rebreather

MPH - Mine Personnel Helmet

MPHA - Mine Personnel Hearing Aid

MPLSS - Mine Personnel Life Support Suit

MPR - Mine Personnel Radio

MPRB - Mine Personnel Rebreather

MPRS - Mine Personnel Rebreather System

MPSG - Mine Personnel Stretch Garment

MPUG - Mine Personnel Undergarment

Miner's Life Support System - MLSS

The Miner's Life Support System (MLSS) was designed to supply cool, breathable, recycled air to a miner wearing a gas-tight suit so he will be comfortable and protected from hostile atmospheres. Off-the-shelf equipment and existing technology was used wherever possible. A radio (Handie talkie) is provided for communication with fellow workers and the mine mouth. A standard hearing aid is used for the sensing of roof and other in-mine noises. Included is an emergency rebreather for use if the prime rebreather should become inoperable.

The MLSS is comprised of the following components:

- The Mine Personnel Life Support Suit (MPLSS) supplied by the Arrowhead Products Division, Federal Mogul Corp., Los Alamitos, California.
- The Mine Personnel Rebreather System (MPRS) and cooling system supplied by the MSA Research Corporation, Evans City, Pennsylvania, and the Cambridge Thermionic Corporation, Cambridge, Massachusetts.

- The Mine Personnel Communications System (MPCS)
supplied by Motorola Communications, Inc., and the
Radioear Corp., Pittsburgh, Pennsylvania.
- The Mine Personnel Emergency Rebreather (MPERB)
supplied by MSA Research Corporation, Evans City,
Pennsylvania.

Mine Personnel Life Support Suit - MPLSS

The Mine Personnel Life Support Suit was designed to operate at 0.5" water column internal suit pressure while circulating 15 cubic feet per minute of cooling air (40% humidity at 70°F) through the suit with a maximum allowable leakage rate of one (1) cubic foot per hour at 7" water column internal suit pressure. To meet this criteria, provide comfort for the wearer and to protect the suit, it was necessary to use a multi-layer system. The MPLSS is therefore comprised of five (5) separate components, (1) The Mine Personnel Undergarment - (MPUG); (2) the Mine Personnel Suit - (MPS); (3) the Mine Personnel Stretch Garment - (MPSG); (4) The Mine Personnel Coverall - (MPC); and (5) the Mine Personnel Helmet - (MPH).

Mine Personnel Undergarment - MPUG

The MPUG is a cotton knit, long underwear readily available in local department stores and commonly worn by miners today. This underwear is used to absorb body moisture thereby providing uniform cooling of the body surface when in the gas-tight suit. The long sleeves and legs also provide protection from chafing at the knees and elbows caused by the Mine Personnel Suit. There are several manufacturers of this style underwear and the final choice will be the individuals' preference.

Mine Personnel Suit - MPS

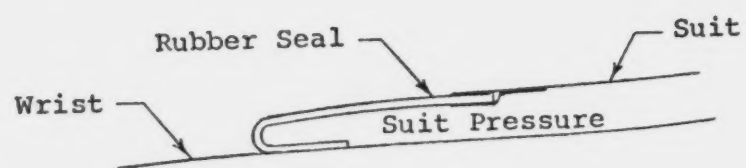
The MPS is the heart of the MLSS and the success of the system depends upon this suit remaining gas-tight. It is made from neoprene-coated nylon cloth. All seams have been sewn and glued for air-tight construction. An air-tight zipper has been provided for donning the suit. The suit is patterned after the fuel handlers suit used at Cape Kennedy and has proven to be reliable during several years use.

Foam neoprene cuffs resembling the storm cuffs on winter jackets are provided at the wrists and calf of the legs to provide a gas-tight seal at these points. The leg cuff

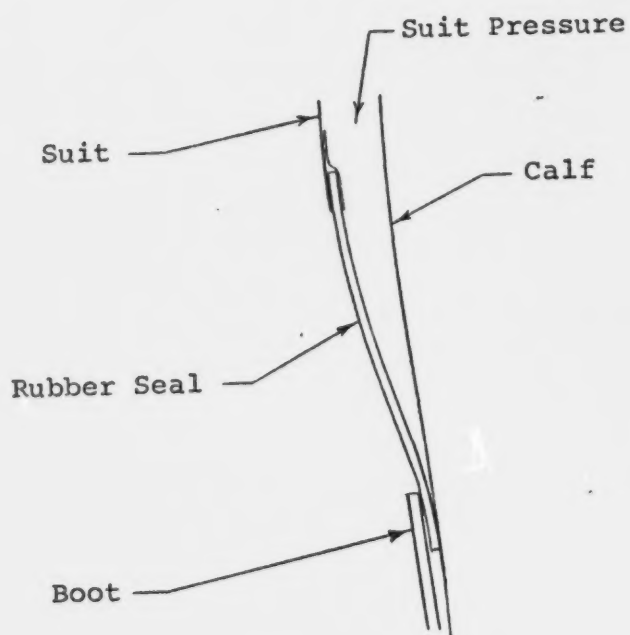
is designed to be in contact with the bare leg, so that the underwear must not be between the leg and the cuff. The cuff is not to be folded under. The stocking covers the cuff and the top of a regular ten (10) inch high boot secures the seal. See Figure 1.

The wrist cuff is to be folded under on bare skin to create the best air-tight seal. A light silicone grease resembling petroleum jelly is used on the wrist underneath the cuff to further minimize air leakage at this point.

The MPS is equipped with two (2) (one green and one gold) positive shut-off tether connectors located in the right breast area. When the tethers are not connected, the valves in the connectors are closed. Inserting the mating fitting on the tether opens the valve and permits air to flow. The green designates incoming air and is connected on the inside of the unit to a series of tubes that distribute the air to the arms, legs, and helmet areas. The gold designates exhaust air being returned from the suit to the rebreather.



Wrist Seal



Calf Seal

FIGURE 1

Mine Personnel Stretch Garment - MPSG

The MPSG is a commercially available garment which has been modified by installing a zipper and openings for the tethers to pass through. These garments are available wherever dancing supplies are sold and are called leotards.

During initial testing of the MLSS, the helmet would rise whenever there was movement within the suit. If the person bent over, the helmet would rise off the head and air would be forced through the wrist and leg seals. The stretch garment prevents the MPS from becoming fully inflated and provides the elasticity for the MPS to expand and contract as the movement of the man forces the enclosed air to different areas in the suit. It also prevents the pressure build-up in the suit which caused the helmet to rise and the suit to vent and provides the elasticity required to maintain a uniform pressure in the MPS.

Mine Personnel Coverall - MPC

The MPC is a commercially available coverall currently used by miners which has been modified to permit the tethers to pass through the coverall. The purpose of the MPC is to

protect the garments underneath from excessive wear and punctures. Experience may reveal the need for additional protection in the knee, elbows, and shoulder areas.

Mine Personnel Helmet - MPH

The MPH, like the MPS, is patterned after the fuel handlers suits used at Cape Kennedy. The ring on the helmet mates with the neck ring of MPS to create an air-tight seal. Two (2) spring-loaded locks are provided to prevent the accidental opening of this seal.

The MPH meets specifications for safety helmets and is equipped with air ducts to distribute air across the visor to prevent fogging. Foam ear cups with receivers and a microphone are also contained in the helmet. The right receiver is connected to a hearing aid and the left to the radio. The microphone permits the direct communication with other miners through the radio. The hearing aid transmits the in-mine noise to the miner.

The visor of the MPH is made of plastic and care must be exercised to prevent scratching. Soft cloths should therefore be used in cleaning the visor. The visor is equipped

with two (2) lever type latches. In an emergency, these can be used to snap out the visor so that the emergency rebreather can be used.

Mine Personnel Rebreathing System - MPRS

The MPRS is comprised of two (2) components, the Mine Personnel Rebreather (MPRB) and the Mine Personnel Chiller Condenser (MPCC). These, when connected by tethers to the MPS and each other, form a closed cycle rebreathing system. MPRB supplying the oxygen and circulating the air, the MPS acting as a breathing bag and the MPCC dehumidifying and cooling the air. When connected in this manner, they form the Miner's Life Support System.

Mine Personnel Rebreather - MPRB

The MPRB is the lung of the MLSS. Its blower supplies breathing air to the MPS and returns the warm, moist exhaust air from the MPS to the rebreather. The rebreather removes the carbon dioxide from the returned air and oxygen is added to replace the oxygen consumed. An oxygen regulator controls the oxygen input into the system and maintains a positive pressure in the suit. An oxygen analyzer continually measures and indicates the amount of oxygen in the system. The unit is designed to provide the oxygen required to maintain a normal working rate for a period of four hours.

The major components of the MPRB are the oxygen bottle assembly including the pressure regulators, which provide and control the oxygen for the system; the carbon dioxide canister which removes the carbon dioxide from the recycled air; a blower which circulates the air through the system; a battery recharge assembly which contains the emergency battery power supply and recharger; and the oxygen monitor which also contains a low-level oxygen alarm. The unit is assembled using quick disconnect and plug fittings for the easy replacement of parts.

The MPRB operates on a 24 volt - DC current supplied by the internal battery power supply of one 24 volt - AC external power. An external plug on the rebreather case is provided to plug in 24 volt - AC power. When the rebreather is placed with the cover up (top) and the 24 volt - AC power is connected, AC power is operating the system and the built-in battery chargers automatically recharge the internal batteries. Upon disengaging, the external power supply, a built-in relay automatically switches over to the 24 volt DC internal battery pack to operate the unit and the battery chargers cease to operate.

Quick positive sealing disconnect fittings located on the end of the rebreather case mate with companion fittings on the tethers. These disconnects are installed in such a manner as to make it impossible to hook them up improperly. The tethers are flexible ducts used to convey the air between the suit and the rebreather. Inside the return tether is a 1/4 inch tubing which extends from the rebreather to the suit connection. This tubing transmits the suit pressure to the rebreather and controls the oxygen inlet to the system. The tubing emerges from the tether at the rebreather disconnect and must be plugged in to its mating plug on the rebreather case to control the oxygen supply to the system.

The oxygen bottle assembly consists of a 2,000 psi, 14 cubic foot capacity steel bottle filled with gaseous oxygen capable of supplying a man at an average working rate for a period of four hours. It also contains a shut-off valve, a pressure regulator, a pressure gage and a filling valve (similar to a tire valve). The shut-off valve controls the flow of oxygen from the bottle. The pressure regulator reduces the discharge pressure of the oxygen from the bottle to 80 psig. The pressure gage (0-3000 psig range) continually indicates the pressure of

the oxygen in the bottle and is independent of the shut-off valve and pressure regulator. The filling valve is used to recharge the oxygen bottle and is also independent of the shut-off valve.

The carbon dioxide (CO₂) canister is an aluminum cylindric can with a removable top filled with four pounds of Baralyme and one pound of Purafill. Two (2) quick disconnect fittings are provided for easy removal from the rebreather. The Baralyme is a pelletized chemical which removes carbon dioxide from the air. The Purafill is also a pelletized chemical which removes odors from the air and converts trace amounts of carbon monoxide to carbon dioxide. The canister was designed for easy recharging. One canister of Baralyme will remove the carbon dioxide from the exhaled air of an average worker for approximately eight (8) hours.

The blower is a commercial blower used in the garment industry. It operates on 24 volt - AC or 24 volt - DC power and circulates 15 cubic feet of air per minute through the MLSS. The system will not operate without the blower. The blower removes the stale air from the suit and replaces it with fresh conditioned air from the rebreather.

The battery recharge assembly contains two banks of three silver-zinc batteries in series. Each bank is equipped with a separate battery recharger, fuses, indicating lights, and tilt switch. These batteries supply the 24 volt - DC power while in transit and provide a one-hour emergency power supply. When external power 24 volt AC is connected to the rebreather, the blower operates on external power and the battery chargers begin recharging the batteries. If the batteries are not upright, the tilt switch prevents the recharging of the batteries. The rebreather must therefore be in the upright position.

The oxygen monitor analyzes and indicates the oxygen content of the air being circulated in the system. The monitor is mounted on the front of the rebreather case so that its indicator is visible when the case is closed. The indicator shows the percentage of oxygen in the system. Should the oxygen drop below 18 percent, a piercing sono-alert goes off alerting the operator to the fact that there is low oxygen in the system and that something must be done. The monitor does not control the flow of oxygen, it only indicates the amount of oxygen in the system.

Mine Personnel Chiller-Condenser-A - MPCC-A

The MPCC-A is a mechanical refrigeration unit, similar to that used in a home refrigerator, equipped with a heat exchanger to cool and dehumidify the air circulated through the MLSS. These are assembled into a 21" x 27" x 12" unit which is permanently mounted on the mining equipment. It is operated by a 110 volt AC power supply on the mining equipment. The MPCC-A also contains a 110 volt AC to 24 volt AC transformer and plug to supply the 24 volt AC power required to operate the rebreather.

Since the MPCC-A is permanently mounted on the equipment, the operator in the portable mode must disconnect the tethers on the rebreather and connect the chiller into the system. Conditioned air now circulating through the MLSS keeps the operator comfortable. He must also plug the 24 volt power supply into the rebreather so that the rebreather is operating on external power and the batteries are being recharged.

The MPCC-A is designed to remove the moisture and cool 15 cubic feet per minute of air to 70°F and 40% relative humidity. A drain valve on the heat exchanger must be opened periodically to remove the water from the system.

The refrigeration system is controlled by a temperature sensor which shuts off the compressor whenever the refrigerant returning to the compressor is colder than 35°F. This is to prevent the icing up or freezing of the water in the heat exchanger. It can be adjusted from 35-45°F to control the temperature of the conditioned air leaving the heat exchanger. This is the only means of controlling the temperature of the air leaving the unit.

The heat exchanger is also equipped with a sample plug that can be used to sample the air being recirculated in the system for testing purposes. It can also be used to inject cleaning solutions that may be required to sanitize the unit. The system, however, may be self-sanitizing. Tests by MSA have indicated that the extreme alkalinity of the Baralyme in the CO₂ canister kills all bacteria in the air stream.

Mine Personneel Chiller-Condenser-B - MPCC-B

The MPCC-B is a thermoelectric condenser-cooler designed specifically for use on the shuttle car. The lack of available space and the need for a 110 volt AC power supply, made the MPCC-A unsuitable for use on the shuttle

car as only 250 volt DC power was available. The MPCC-B is 9" x 9" x 12" and weighs approximately thirty pounds or 1/4 the weight of the MPCC-A. A special power pack converts the 250 volt DC power to 96 volt DC to operate the thermoelectric unit.

The MPCC-B has no mechanical parts other than the four small fans required to cool the unit. It is designed to dehumidify and conditions 15 cfm of air to 70°F and 40% relative humidity. A drain valve is provided for the removal of condensate.

The MPCC-B and power converter are permanently mounted on the shuttle car. The convertor voltage can be varied to permit the operator to adjust the temperature of the recycled air. The condensate drains into a small bottle preventing mine atmosphere from entering the system.

The MPCC-B does not contain a 24V AC power supply for the rebreather. A 250V DC to 115V AC motor generator and a 115V AC to 24V AC transformer are used to provide the necessary 24V AC power for operating the rebreather.

Mine Personnel Communications System - MPCS

The MPCS is comprised of two basic off-the-shelf components, a radio transceiver (walkie-talkie) and a standard hearing aid. The transceiver in conjunction with a transmitter and in-mine antenna system, provides direct communication between the miners and the mine mouth. The hearing aid permits the miner to hear the in-mine noise such as roof noises, etc. The receivers for these units are mounted in the foam ear cups in the MPH. The hearing aid to the right ear and the radio to the left. The radio is carried on the miner's belt while the hearing aid is carried in the coverall pocket.

Mine Personnel Radio - MPR

The MPR is aa standard F.M. transceiver manufactured by the Motorola Corporation. It is carried in a leather holster on the belt and is equipped with an 8" antenna. A voice-operated relay (VOX unit) is also carried on the belt. The VOX unit is connected to a remote speaker and microphone mounted in the helmet and it automatically operates the microphone whenever the person speaks. It is not necessary to press a button to operate the microphone. The radios are battery-powered and will operate for 12 hours before the batteries must be recharged.

The heart of the communications system is a transmitter located at the mine mouth. This is connected to an antenna which extends into the mine along the haulage way and across the last open crosscut to provide complete coverage of the section. The antenna radiates a signal into the mine which is picked up by the antenna on the transceiver and broadcast to the man. When the man speaks, the 8" antenna on the transceiver emits a signal which is picked up by the main antenna and conveyed to the transmitter at the mine mouth. The transmitter amplifies the signal which is then broadcast in the control room.

It is possible for section members to talk direct to each other only when the signal is being transmitted directly from one transceiver to the other. The conversation will also be heard in the control room if they are within the range of the antenna. Should the men be within the range of the antenna and be unable to talk directly to each other, the antenna will pick up the signal and the message will be broadcast in the control room. The controller will then have to rebroadcast the message to the party concerned. All persons in the mine will hear the controller.

The signal emitted by the main antenna is rapidly absorbed by the mine and the situation may develop where it is possible to see the antenna and still not be able to talk to the controller. It is necessary to be within approximately 50 feet of the antenna for it to work. Actual experience in the mine may prove this distance to be 150 feet or ten feet. If unable to communicate with the controller, you may have to go closer to the antenna for your signal to be picked up.

Mine Personnel Hearing Aid - MPHA

The MPHA is a commercially available hearing aid that has been slightly modified for use in the system. The familiar ear plug of the hearing aid has been replaced with a speaker located in the right foam ear cup in the helmet. The wire passes through the helmet and is plugged into the hearing aid carried in a pocket of the coverall.

Since the hearing aid's primary function is to amplify the sound for those that are hard of hearing, it was necessary to adjust the volume output so it would not harm a person with normal hearing. The hearing aid in this use is to provide a means of hearing noises outside of the suit and to slightly amplify this noise.

Since the hearing aid picks up the noise at one point and relays the sound to one ear, it may be difficult to determine the direction of the noise. As a result, the user may have to adjust his senses to correct for this. It may be necessary to develop a special hearing aid that will duplicate the function of the normal ear and provide directional hearing. It may have to pick up the noise outside the helmet opposite the ears and relay the sound to speakers in the ears.

Mine Personnel Emergency Rebreather - MPERB

The MPERB is to be carried by the miner at all times and in case the primary life support system fails, it will provide 45 minutes of oxygen to permit the man to reach safety. It is a commercially available unit manufactured in Germany, and is the recommended self-rescue unit for use by the German Mining Industry.

The MPERB contains a canister of potassium superoxide, an oxygen candle, a rebreathing bag, a bite mouth piece and a nose clamp. To put the system into operation, the unit is removed from its container and the carrying loop slipped over the head. The bite mouth piece is placed in the mouth held firmly by the teeth and the nose clamp is clamped on

the nose. Exhale into the bite mouth piece at the same time pull the O ring attached to the trigger mechanism. The striker ignites the oxygen candle which burns and generates pure oxygen helping to inflate the breathing bag and supplying oxygen for immediate use. The nose clip forces the user to breath through the bite mouth piece so that outside air cannot enter the system. Inside the canister, the carbon dioxide and moisture in the exhaled air react with the potassium superoxide and the carbon dioxide is converted to gaseous oxygen. Potassium superoxide is used as the oxygen source for some of the equipment currently used in mine rescue work.

In use, the canister becomes quite hot. However, the unit has been designed to protect the user from this heat. Care therefore should be exercised when removing the unit. Once activated, it will continue to generate oxygen even though no one is breathing into it. The discarded unit should therefore be placed in a well-ventilated area away from highly combustible gases and other materials to prevent a possible fire or explosion. Whenever possible, it should be immersed in a bucket of water to stop the formation of oxygen.

Appendix D contains the manufacturers' instructions for operating the unit. These instructions should be memorized and routinely practiced as this knowledge could be a matter of life or death in case of an emergency.

OXYGEN, CARBON DIOXIDE, AND CARBON MONOXIDE

Certain hazards are involved with the use of any life support system. The percentage of oxygen, carbon dioxide and carbon monoxide in the system can be critical. The various components in the rebreather are designed to add oxygen as required and to remove carbon dioxide and carbon monoxide from the recycled air. In this life support system, the compressed oxygen supply serves a dual purpose. It not only supplies the make-up oxygen to the system, it also replaces the volume of gas lost from the system due to leakage. This causes a gradual increase in the amount of oxygen in the recirculated air and over an extended period of time could create problems.

OXYGEN

The rebreather contains fourteen cubic feet of compressed oxygen at 1800 psi and is designed to supply 0.2 pounds of oxygen per hour. This amount of oxygen can sustain a man at a moderate work rate for four hours and for a longer period if at rest. Any oxygen lost from the system through leakage will decrease the length of time the rebreather can be used. It is therefore essential to minimize the leakage from the system in order to obtain maximum use

of the available oxygen. The oxygen flow into the MLSS is controlled by a pressure regulator set to maintain 0.5" water column pressure in the suit. A tube located in the return air tether runs from the pressure regulator in the rebreather to the suit where it senses and controls the pressure in the suit at this point. Oxygen from the regulator is injected into the system just after the blower in the rebreather and goes directly to the suit. The regulator receives no other signals. Its only function is to maintain the system at 0.5" water column.

The consumption of oxygen by the user causes a drop in pressure in the system and the injection of additional oxygen by the regulator. Normal activities within the suit cause a fluctuation in internal suit pressure which also causes leakage from the system. This has a greater effect on the amount of oxygen injected into the system than the actual oxygen consumed. As a result, there will be a gradual increase of oxygen in the system which could exceed 50%.

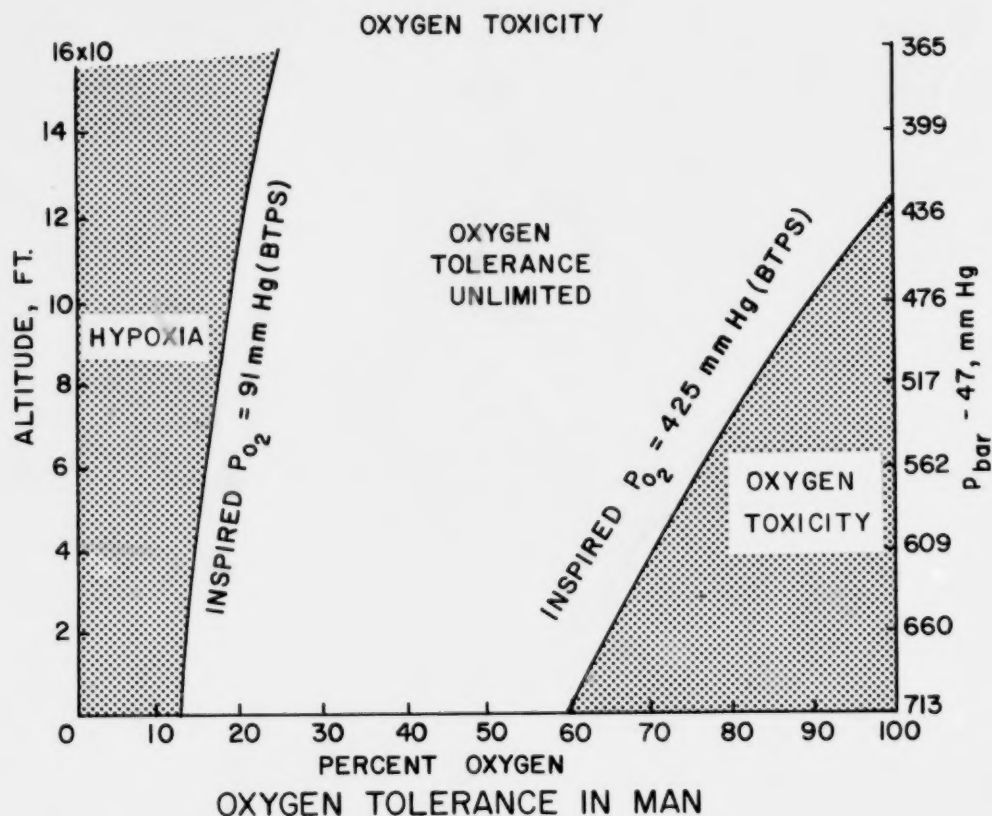
Since there is the possibility of excessive amounts of oxygen in the system, the question was raised on what effect this would have on the man. A review of work done by the Navy, Air Force, and NASA indicates a man can safely breathe 100% pure oxygen for a period of eight to

ten hours before experiencing any ill effects and most effects are related to the dryness of the oxygen breathed. We do not anticipate the oxygen in the system to reach 100% nor will we be breathing this air for more than four hours at any one time. In addition, the air circulating in the system will pick up moisture from the body so dry air should not be a problem. Figure 2 shows the oxygen toxicity limits established for the continuous use of oxygen over a several day period.

There should be no health problems associated with breathing 50% oxygen for limited periods of time (two-four hours) on a regular basis. However, individuals can react differently, and there could be exceptions to this. All personnel should therefore become familiar with the problems associated with breathing oxygen-rich air and be alert to the way their bodies react to it.

CARBON DIOXIDE (CO₂)

A part of the oxygen inhaled into the lungs is converted to carbon dioxide which is exhaled along with the surplus oxygen not utilized by the body. If we rebreathe this exhaled air, the body could use the surplus oxygen until it



(After Mullinax and Beischer.)

Space Cabin Atmospheres

FIGURE 2

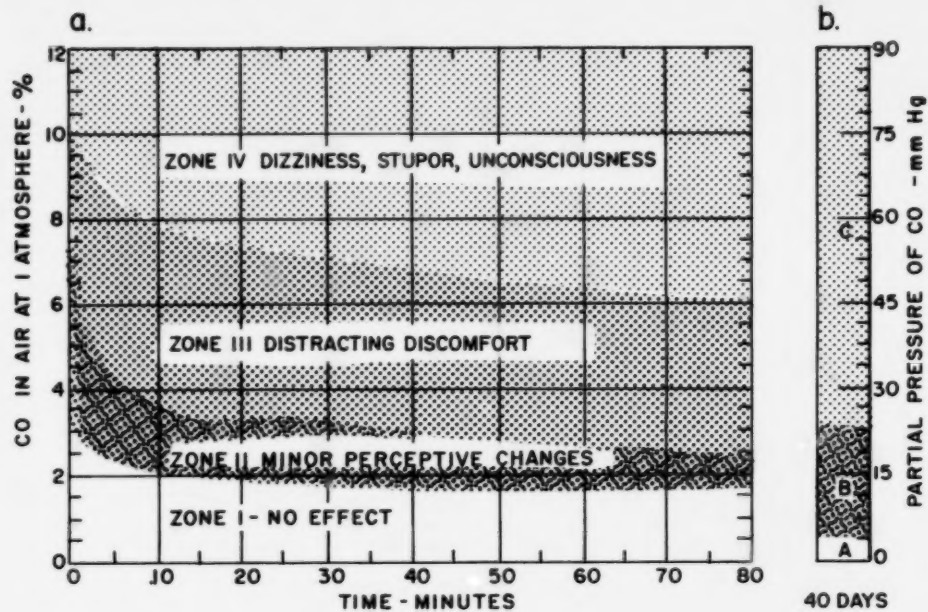
was completely consumed. However, the carbon dioxide concentration would soon increase to the point where it would have a toxic effect on the body. It is therefore essential in any system requiring the rebreathing of exhaled air that the carbon dioxide be removed.

Since carbon dioxide has a toxic effect on the body, it is essential to become familiar with how various concentrations of carbon dioxide affect the body. Figure 3 shows the effects of the % of CO₂ versus time and indicates that up to 2% CO₂ can be tolerated for an extended period of time with no ill effects on the body.

Two to four per cent carbon dioxide can be tolerated for an extended period of time. The effects on the body range from minor perceptive changes to distracting discomfort (see Figure 4) including an increase in the depth of breathing (respiratory volume) and a slight increase in the respiratory rate. There would be no noticeable change in pulse rate.

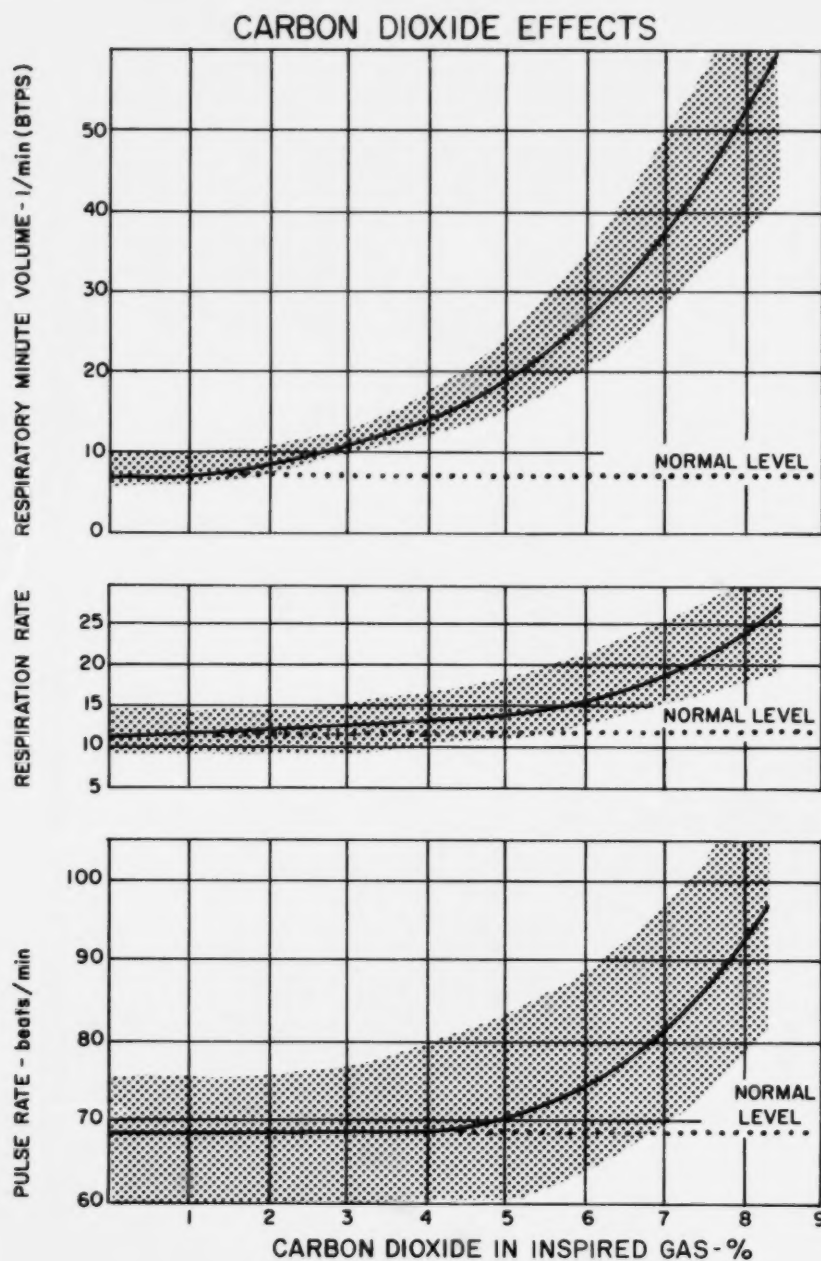
Distracting discomfort is experienced with carbon dioxide concentrations between four to six percent. At these concentrations, there is a considerable increase in the depth of breathing accompanied by an increase in the respiration

CARBON DIOXIDE EFFECTS



Sources: Drawn from data of King (9), Nevison (13), and Schaefer (20), via Bioastronautics Data Book

FIGURE 3



Sources: Adapted from Schaefer et al. (21) and Dryden et al. (6), via Bioastronautics Data Book

FIGURE 4

and pulse rate. In spite of this discomfort, man can safely work in this atmosphere for 60 minutes or more. These symptoms should, however, alert the individual that there is a build-up of carbon dioxide in the system indicating that the CO₂ canister is exhausted and a new canister is required. Recognizing these symptoms, the individual should proceed immediately to safety and remove the rebreather.

Carbon dioxide concentrations between six and eight per cent can be tolerated for relatively short periods of time-- 10 minutes or less. During this period, there would be distracting discomfort possibly accompanied by dizziness. Exposures beyond 10 minutes could cause dizziness, stupor, and unconsciousness accompanied by extremely rapid deep breathing and a relatively rapid pulse rate. Recognizing the onset of these symptoms, the individual should proceed with haste to safety and fresh air.

All rebreathers should be recharged with oxygen and a fresh CO₂ canister after each use and therefore there should always be less than 2% CO₂ in the system. The CO₂ concentration could accidentally go beyond 2%. It is therefore

essential to be alert to the symptoms of CO₂ toxicity at all times.

The distracting discomfort at four to six per cent carbon dioxide should be distinguishable enough to alert the individual to the problem and permit him to reach safety.

The cylindrical container in the rebreather is the CO₂ canister whose function is to remove the carbon dioxide from the recirculated air. It is filled with four pounds of Baralyme which can absorb 0.5 pound of carbon dioxide per pound and will remove the carbon dioxide for a considerably longer period than the four hour service life of the rebreather.

The canister also contains one pound of Purafil whose function is to remove odors and traces of carbon monoxide that may be in the system. The Purafil can be reused many times before it loses its reactivity. Purafil was chosen over activated carbon because of its extended life and because of its ability to convert small quantities of carbon monoxide into harmless carbon dioxide.

The carbon dioxide (CO₂) canister is designed for easy recharging. To recharge, the canister is removed from the rebreather and the retaining ring removed. The cap and

spring-loaded plate are removed as well as the sack containing the Purafil. The spent Baralyme is emptied into the trash container. The canister is then wiped out with a clean cloth to remove any dust or Baralyme.

To recharge the canister, take two one quart cartons of Baralyme (2 pounds per carton), and slowly pour the contents into the canister while continually tapping the canister to compact the Baralyme. Replace the filter cloth and sack of Purafil, insert the spring-loaded back-up plate, slip on the end cap and install the retaining ring. Check the canister to make sure there are no leaks.

The Baralyme is initially pink in color. As it absorbs CO_2 , it changes from pink to blue, indicating that it can no longer absorb carbon dioxide and must be replaced. The CO_2 canister is equipped with a small glass window in order to observe this color change and to check the condition of the canistr.

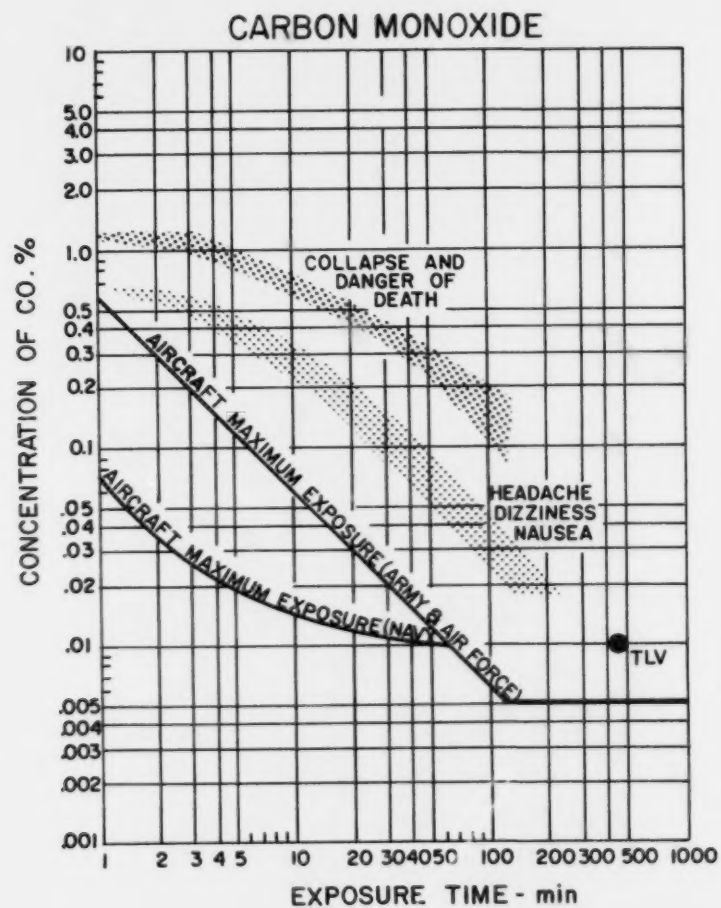
CARBON MONOXIDE

As mentioned above, Purafil is used in the CO_2 canister to convert carbon monoxide to harmless carbon dioxide. There should be no carbon monoxide in the recycled air; however, the gas proposed for blanketing the mine could contain

as much as 2% carbon monoxide. Should a leak develop in the life-support system where mine atmosphere leaks into the system, carbon monoxide could be a problem. The Purafil renders this carbon monoxide harmless by converting it to carbon dioxide.

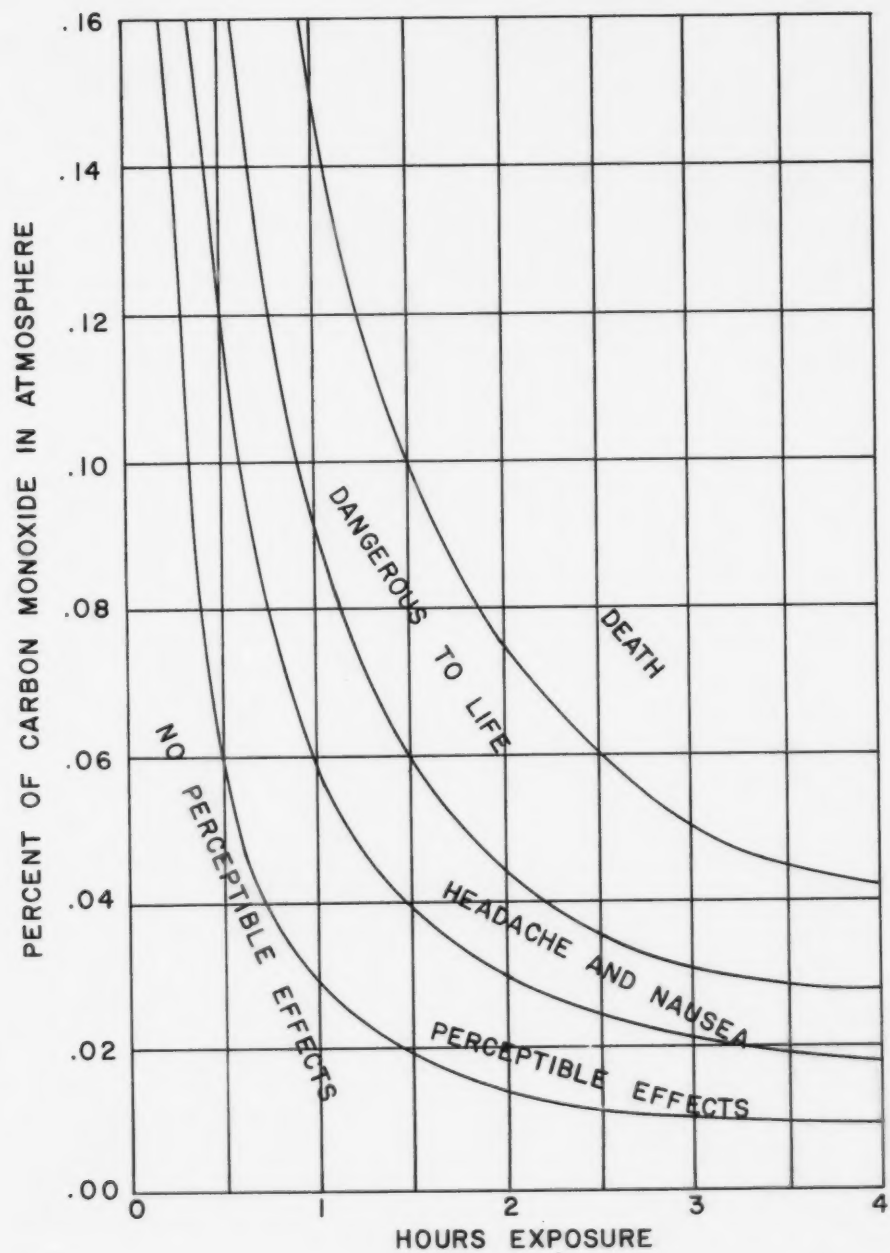
Figures 5 and 6 will help to develop a better understanding of carbon monoxide and its effect on the body. The maximum recommended concentration of carbon monoxide in air having no perceptible effects on the body is 0.0035%. As little as 0.02% carbon monoxide over an extended period of time can cause headaches, dizziness, and nausea and as little as 0.1% carbon monoxide can cause death. Carbon monoxide is extremely toxic while carbon dioxide is harmless.

It is to be concluded that there should be no health problems related to the use of oxygen even if on occasions the oxygen concentration should reach 100%. Headaches, dizziness, nausea, and rapid deep breathing are warning symptoms indicating excess carbon monoxide or carbon dioxide in the system. Upon recognizing these symptoms, the individual should immediately seek the safety of fresh air.



Sources: Department of Defense (5), Haldane (7), Henderson and Haggard (8), and Sayers et al. (14), via Bioastronautics Data Book

FIGURE 5



EFFECTS OF CARBON MONOXIDE FOR A GIVEN TIME ON HUMAN BEINGS

FIGURE 6

OPERATING INSTRUCTIONS FOR THE MINER'S LIFE SUPPORT SYSTEM

The following procedures will be followed when placing the Miner's Life Support System in operation.

System check-out and start-up:

- Pick up the Life Support Suit, at the service and storage room and don the suit.
- Obtain the rebreather, helmet, radio, hearing aid, emergency rebreather and miner's light at the service and storage room and proceed to the final checkout area.
- Place the rebreather, helmet, radio, hearing aid, emergency rebreather and miner's light on the workbench beside the air cooler.
- Insert the blue connector on the tether fastened to the air cooler into the green connector on the tether to the suit and open the air supply valve located on the air cooler. Cool air circulating through the suit and exhausting through the neck ring will keep you comfortable while checking the rebreather. If

no cool air enters the suit, check to see if the air supply valve is open and if the air blower is operating. See Figure 7.

- Open the cover of the rebreather and check the service record to see when the rebreather was last used and serviced. If it has not been serviced since the last use, return to service area and secure another rebreather.
- Check the pressure gauge on the oxygen bottle. The pressure should be 1,800 psi or more.
- Check window in the carbon dioxide canister to make sure the canister is full and the baralyme is pink. A blue color indicates the baralyme is exhausted and the canister has not been recharged. Secure and install a new canister.
- Connect the tethers and the oxygen control line to the rebreather. These can be connected in only one way-- green to green and yellow to yellow.
- Plug in the 24 volt power supply to the rebreather. The white panel light on the rebreather will come on indicating the unit is connected to external power.

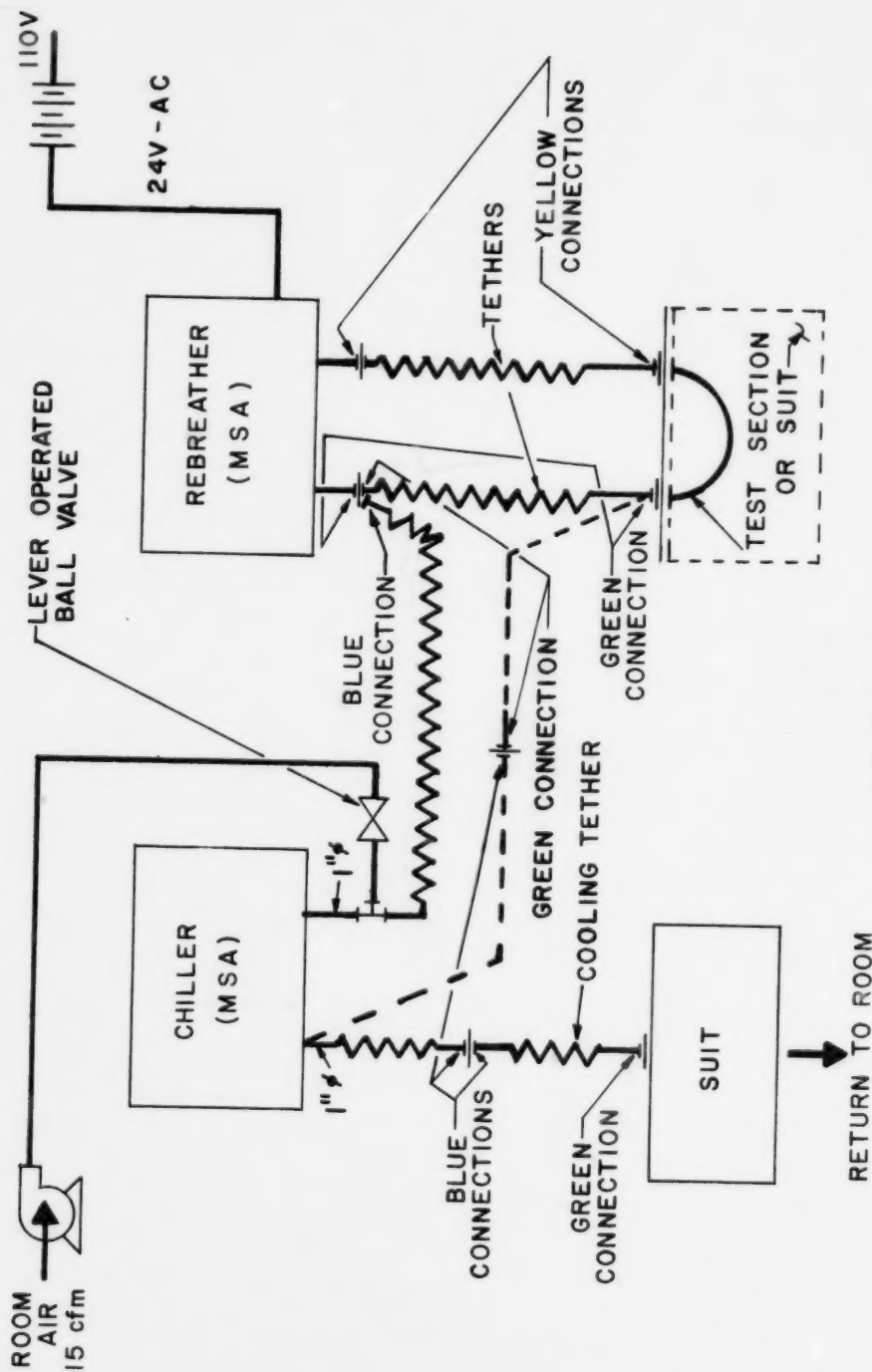


FIGURE 7
CREW COOLING SYSTEM FOR
TEST AND ASSEMBLY AREA

- Check the green lights on the battery charger. If the lights are on, the batteries are not completely charged and the unit should be returned to service room for a different rebreather. If the lights are out, the batteries are fully charged and the unit is ready for use.
- Check the suit pressure gauge. It should indicate zero. If not, use a small screw driver to turn the adjusting screw until zero pressure is indicated.
- Turn on the blower by moving the switch on the rebreather to the on position.
- Switch on the oxygen monitor and check the indicator for the percent oxygen in the system. This should read 21 percent. If it does not, push the battery test button on the monitor to determine the condition of the battery in the oxygen monitor. If the indicator moves to the green area, the battery is good and the monitor needs to be recalibrated. If it does not move to the green area, the battery needs to be replaced after which the monitor must be recalibrated.

To calibrate the monitor, use a small screw driver to turn the adjustment screw located on top of the monitor inside the rebreather. Slowly turn this screw until the needle indicates 21 percent. This calibration must be done while the blower is circulating air from the room through the rebreather. The room air is used as the standard air.

Previous testing in the room could cause an increase in the oxygen content of the room air and thus cause a false calibration. Care should therefore be exercised to minimize the amount of oxygen exhausted into this room and the room should be well ventilated.

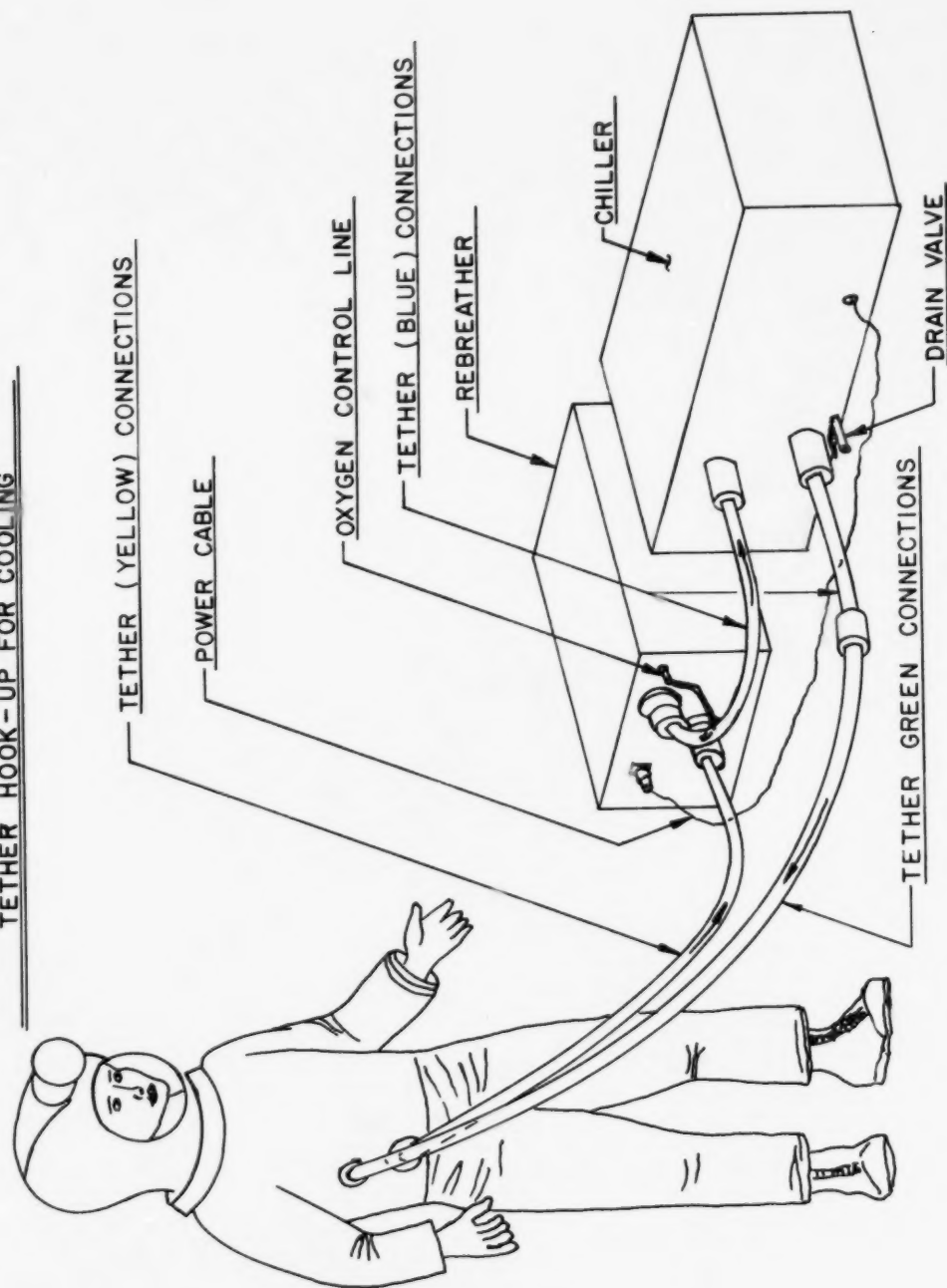
- Turn off blower in the rebreather and using the test section connect the ends of the tethers using the suit connectors to each other so the system is air-tight and air can recirculated through the rebreather and tethers.
- Turn on the blower and open the air inlet valve. If the gauge indicating suit pressure does not show an increase in pressure check the oxygen sensing line to make sure it has been connected to the rebreather. This pressure gauge will not operate unless this has

not been done. Check to see that all connections have been made and check all joints for leaks.

- Turn off the blower.
- If a pressure greater than 1" water column is indicated open the air inlet valve to bleed off the excess pressure until the gauge reads approximately 0.5" water column, then close the air inlet valve.
- Observe the pressure gauge to determine if the pressure remains constant. This indicates the system is air tight and ready for use. If the pressure drops, there is a leak in the system. Using leak-tec, check all fittings and joints for air leaks, tighten any leaking fittings, and recheck for further leaks. If unable to stop the leak, return the rebreather or tethers to the service room and secure another one. If satisfied the system is tight and ready for use, sign and date the service sheet and continue to hook up the life support system.
- Remove the test section from the tether suit connectors and insert the yellow tether connector into the mating fitting on the suit.

- Close the air supply valve on the air cooler and disconnect the cooling tether from both the suit and the air cooler and lay on the bench. There is no further need for this tether at this time.
- Disconnect the green tether from the rebreather and connect the mating blue tether from the air cooler to the rebreather. This connection can only be made one way and no mistake can be made.
- Connect the green tether previously disconnected from the rebreather to the mating blue connector on the air cooler and to the mating connection on the suit. See Figure 8.
- Put on the radio, hearing aid, emergency rebreather, and lamp battery.
- Put the miner's lamp on the helmet and put the helmet on but do not close the neck ring.
- Plug in the hearing aid and radio, turn them on and check to make sure they are operating properly. If satisfied, continue with the hook-up of the life support systems.

FIGURE 8
TETHER HOOK-UP FOR COOLING



- Close the helmet neck ring. Make sure ring is properly sealed and the locks are closed.
- Open the air inlet valve and turn on the blower. The amber light (empty) on the control panel will be on. Ignore this light as it will go out and the green one will come on when the air inlet valve is closed. If this does not happen, there is a blockage in the CO₂ canister and no air will circulate through the suit.
- Observe the suit pressure gauge, when the pressure reaches 0.5" water column, close the air inlet valve and turn off the blower.
- Stand perfectly still and observe pressure gauge. If the indicator remains constant, the system is tight and ready for use. If there is a rapid drop in pressure, check to see that the air inlet valve is closed. Check the suit for proper helmet ring and zipper closures as well as for other sources of leaks. When satisfied the system is tight, proceed with the system start-up.
- Turn on the blower and open the air inlet valve.

- When the suit pressure gauge indicates 1" water column pressure, close the air inlet valve and note the reading of the oxygen monitor. It should be 21%.
- Open the oxygen feed valve. You should hear a short burst of oxygen entering the system even though the suit pressure is above the control point. This is caused by a momentary delay in the oxygen regulator. The oxygen monitor at this point should read approximately 25 percent.
- To check the operation of the oxygen regulator, turn off the blower, open the air inlet valve and gradually vent the suit pressure until you hear the oxygen regulator feed oxygen into the system. Immediately close the air inlet valve. You are now at the control pressure of the system. 0.4-0.6" water column. There will also be a slight increase in the percent of oxygen in the system.

If the suit pressure drops to zero and the oxygen regulator did not begin to feed oxygen, check the oxygen feed valve to make sure it is open. If this does not correct the problem, the regulator is faulty. Return the rebreather to the service area and secure another

one and proceed as before. When satisfied all systems are working properly, turn on the blower and proceed with the system start-up.

- Close and latch the rebreather cover and wait until all members of the crew are ready to enter the mine. During this wait, the air cooler will provide cool air to keep you comfortable.
- When the crew is ready, disconnect the blue-green tether connecting the cooler to the rebreather and to the suit. During this time the air flow will stop; however, the blower continues to run.
- Connect the green suit tether to the rebreather. Air will now circulate through the suit.
- Disconnect the 24V AC power cord from the rebreather. The life support system is now in the portable mode and you are ready to enter the mine.
- Pick up the rebreather and proceed to the mine. The portable mode permits you to carry the rebreather and walk about; however, it does not provide cool air for your comfort and you will soon become quite warm. It is essential that you immediately proceed to your work station so that you can connect to the air cooling unit at that location.

Entering the Mine

The suited miner with the MLSS in the portable mode must pass through a personnel lock located at the mine mouth in order to enter the mine. The personnel lock is an air-tight chamber whose function is to prevent the gaseous mine atmosphere from mixing with the normal outside air to cause an explosive condition. During the operation of the lock, an oxygen-free purge gas sweeps through the lock and exhausts through an automatic vent valve to the atmosphere. An analyzer in the lock automatically shuts down the purge cycle when the composition of the exhaust gas is the same as the purge gas. The lock now contains the oxygen free purge gas and it is safe to enter the mine. The purge cycle will automatically be initiated and the lock purged whenever the analyzer indicates the air in the lock is of a different composition than the purge gas.

On approaching the personnel lock, observe the panel of indicating lights consisting of three groups of two lights. One set of lights indicates the conditions of the near door--locked or unlocked. Another set indicates the condition of the opposite door--locked or unlocked. The third set indicates the condition of the personnel lock--purge in progress and purge complete. Also located by the door

is a push button to control the entrance into the personnel lock.

The following procedure is used to enter the mine:

- Make sure the panel lights indicate both doors are locked and the purge is complete.
- Push the button to unlock the door and to turn off the automatic purge system. This unlocks the door next to the pushbutton station. The door will not unlock if the opposite door is unlocked or if a purge cycle is in progress.
- Open the door and enter the personnel lock.
- Close the door and push the button on the inside of the personnel lock. This locks the door and reactivates the automatic purge cycle.
- Observe the panel of indicating lights. This panel is identical to the one on the outside of the lock. The purge in progress and both door-locked lights should be on. If either door is unlocked, the automatic purge will not operate.

- Wait in the lock until the purge-in-progress light goes out and the purge-complete light comes on. It is now safe to proceed.
- Push the button beside the door you wish to open. This unlocks the door and turns off the automatic purge system. The opposite door should remain locked.
- Open the door and enter the mine.
- Close the door and push the button to lock the door. Should you forget to do this, a time delay device will automatically lock the door after a pre-determined length of time, thereby securing the lock and making it possible for someone to enter from the other side.
- A panel identical to the ones on the outside and the inside of the lock is also located inside the mine. Check this panel to make sure the door-locked light is on.
- Proceed with the in-mine activities.

Personnel Carrier (Porta-bus)

The porta-bus is a crew-sized vehicle used to transport the miners to the working face. It is equipped with individual coolers and power supplies for each miner's life support system in order to keep him comfortable and conserve the batteries in the rebreather while in transit to the working area. The following procedure is used upon entering the mine.

- Crawl into the porta-bus and lay on your back.
- Secure the rebreather into the overhead rack.
- Connect the tethers from the rebreather to the chiller located on the carrier.
- Turn on the chiller control switch.
- Plug the 24V power supply into the rebreather.

Remain in this position until the man train arrives at the face.

- Disconnect the external power supply from the rebreather.

- Disconnect the tethers from the chiller and hook up to the portable mode.
- Crawl out of the porta-bus.
- Proceed to your work station with the life support system in the portable mode.

Procedure at Mining Equipment

- Inspect the equipment to determine its state of repair and if it is ready to operate.
- Report to the section boss on the radio and have him throw the circuit breaker to energize the mining equipment.
- Place and secure the rebreather in its rack.
- Plug in the 24V power supply from the chiller.
- Disconnect the green tether from the rebreather.
- Connect the blue tethers from the chiller to the rebreather and the green tether.

- Drain the water from the chiller.
- Cool air should be circulatingg through the suit and you are ready to begin work.

Rest Period

There will be an extra man on each crew who will relieve each miner in turn so they may go to the refuge station for relief and lunch. The relief man, riding a boss car, drives up to the miner to be relieved, disconnects his rebreather from the chiller and the power supply on the boss car and exchanges places with the miner being relieved. The relieved miner connects his rebreather to the boss car and drives to the refuge station. At the end of his rest period, he returns to his piece of equipment and exchanges places with the relief man who then proceeds to relieve the next man.

Refuge Station

The refuge station is a room in the mine constructed close to the working face. This room is sealed off from the mine and fresh air is continually supplied to the room. A gas lock similar to the personnel lock is provided for access

into the room. In the refuge station, the life support system can be shut down and removed in order to eat lunch or relieve oneself. Emergency supplies and direct communication to the outside are provided to make this a refuge area in case of an emergency. Operating in the same manner as the personnel lock at the mine mouth, the gas lock is used to enter the refuge station. The indicating lights at the entrance door signify the condition of the lock and the same procedures established for operating the personnel lock are used to enter the refuge station. On entering the refuge station, place the rebreather on the work bench and proceed as follows:

- Open the rebreather cover and close the oxygen supply valve while the blower is still running.
- Open the helmet seal ring, disconnect the radio and hearing aid and remove helmet.
- Plug the 24V power supply into the rebreather.
- Disconnect the gold tether from the suit. Air from the room is now circulating through the rebreather and exhausting out of the neck ring of the suit into the room. This provides cooling and purges oxygen-enriched

air from the suit and should continue for five minutes.

- Turn off the rebreather blower, disconnect the green tether from the suit and move freely about without any tethers.
- If additional cooling is required, a small blower has been provided at the lunch table to circulate room air through the suit without passing through the rebreather. To utilize this, reconnect the green tether to the suit, then disconnect it from the rebreather and connect it to the blower manifold. Turn on the blower to circulate air through the suit.
- To put the life support system back into service, disconnect the tether from the room blower and follow the previously established start-up procedures.
- Pass through the refuge station gas lock, return to your work station, exchange places with the relief man and resume operating your machine.

Leaving the Mine

At the end of the work shift, secure the mining equipment, disconnect the rebreather from the chiller and power supply, and notify the foreman by radio to turn off the electricity to the machine. Proceed in the portable mode to the man train. Repeat the boarding procedure previously used when boarding the porta-bus. On reaching the mine mouth, dismount from the porta-bus, pass through the personnel lock and return to the assembly area. Shut down the rebreather equipment, purge the oxygen from the suit, return the life support equipment to service and storage room and wash up.

Shutdown Procedure

The following are procedures to be followed when shutting down the Miner's Life Support System (MLSS):

- Temporary shutdown - system to be reused after a rest period:
 - Open the rebreather cover and close the oxygen supply valve while blower is still running.
 - Open the helmet seal ring, disconnect the radio and hearing aid and remove the helmet.

- Plug the 24 volt power supply into the rebreather.
- Disconnect the gold tether from the suit. Room air is now circulating air through the rebreather and exhausting out the neck ring into the room. This provides cooling while purging the oxygen enriched air from the suit and should continue for five minutes. Under no circumstances should there be any smoking by or near the man while this is taking place.
- Turn off the rebreather and disconnect the green tether from the suit and move about freely without any tethers.
- To put the system back in service, follow the start-up procedures.
- Complete shutdown and system removal
 - Open the rebreather cover and close the oxygen supply valve while the blower is still running.
 - Open helmet seal ring, disconnect the radio and hearing aid, remove the helmet.

- Plug 24 volt power supply into rebreather.
- Disconnect the gold tether from the suit and let the rebreather run for five minutes to purge excess oxygen from the suit. Under no circumstances should there be any smoking by or near the man while this is taking place.
- Shut off the rebreather.
- Disconnect the green tether from suit and both tethers and the oxygen control line from the rebreather.
- Disconnect the 24 volt power supply.
- Record number of hours the rebreather was used on the enclosed service sheet. Close and latch cover.
- Return the rebreather, tethers, radio, helmet, and hearing aid to the service and storage room.
- Remove the life support suit and return them to service and storage room.
- Proceed to wash up.

- CAUTION!! During the use of the MLSS, the oxygen concentration in the system could exceed 50%. This could present a serious fire problem, and extreme care should be taken to purge this oxygen out of the suit before removing it. There should be no open fires or smoking near the individual and the room should be well ventilated. Caution should also be exercised after removing the suit as oxygen can still be trapped in the underwear and could still be a potential fire hazard.

Servicing the Life Support System

After every use, the MLSS will be returned to the store room for servicing. The person returning the unit will report any trouble that may require servicing beyond the normal recharging and cleaning. After the units have been serviced, they will be placed in the storage racks and the rebreathers will be plugged into a 24V power source. This automatically starts recharging the batteries in the rebreather so that the batteries will be fully charged for their next use.

Rebreather

The rebreather will be serviced according to the operating and maintenance manual supplied by MSA Research Corporation. A complete service record (Figure 9) for each unit will be maintained and affixed to the cover plate of the rebreather so that the next user knows who serviced the unit, what was done, and when. Routine checks will be made for leaks to assure system integrity. All gauges will be calibrated as required.

Rebreather No. _____

[illegible]

61

Life Support Suit

Inspect the life support suit for tears and wear points and patch these areas as required. Wash the suit inside and out with soap and water and hang up to dry.

Wipe off the areas requiring patches with toluene to remove grease and dirt and soften the material. The patch, cut to the appropriate size, is also cleaned with toluene. Apply a thin coat of adhesive to both the suit and the patch and allow to dry until tacky--approximately 10 minutes. Apply a second coat of adhesive and allow to dry until tacky. Place the patch in position apply pressure and roll to complete the repair. Maximum strength will be developed in 24 hours. The suit should not be used except in emergency for at least 48 hours or until no adhesive odor is detected.

You will observe the suit material has a rubber side and a fabric side. The strongest repair is made by bonding the rubber side of the suit to the rubber side of the patch. The next strongest repair is bonding the rubber to the cloth, and the weakest repair is bonding cloth to cloth. A proper repair will be gas-tight and will be stronger than the original suit material.

Should the leg or wrist cuffs tear, clean the edge of the tear with toluene to remove grease and dirt. Apply one coat of adhesive and allow to dry until tacky. Apply a second coat of adhesive and allow to dry until tacky. Place cuff on a flat surface and press the edges of the tear together. Allow to cure for 24 hours. The repair will be gas-tight and the cuff as strong as before it tore.

Care should be exercised in making the suit repairs that the proper adhesive is used.

Tethers

Inspect the tethers for breaks and wear points after cleaning with a soapy sponge and water. Check them for leaks. Repair using the recommended adhesive for the job. If it is impossible to stop the leak, install new tethers.

Radios

Wipe off the radios, test them, and repair any malfunctions. Place the radios in the battery charger so they will be recharged for use the following day. Fresh, recharged

batteries can be placed in the radios if they are required for use on the second and third shifts. The used batteries can be placed in the charger for recharging.

Hearing Aids

Wipe off the hearing aids, test them, and correct any malfunctions. Place them in the respective battery chargers so they will be ready for use the following day.

Helmet

Wipe the helmet inside and out using a sponge and soap and water. Polish the visor and place the helmet on the shelf, ready for the next day's use.

APPENDIX B

OPERATING AND MAINTENANCE MANUAL-MSA

IMPORTANT WARNING

The MSAR Mine Personnel Rebreathing System (MPRS) will do the job it is designed to do only if it is used and serviced in accordance with the manufacturer's instructions. This manual must be carefully read by all individuals who have or will have the responsibility for using or servicing the product. The warranties made by Mine Safety Appliances Company with respect to the product are voided if the product is not used and serviced in accordance with the instructions in this manual. Please protect yourself and your employees by following them.

GENERAL INFORMATION

This manual provides a description and instruction for operating the Mine Personnel Rebreather System herein referred to as the MPRS.

This unit is a development model to investigate the feasibility of mining coal while the miner is wearing the Mine Personnel Suit (MPS). A design goal was to use off-the-shelf hardware in fabricating the units.

The MPRS provides a 4 hour O₂ supply utilizing compressed O₂, baralyme for CO₂ removal, and Purafil for odor removal. The MPRS is a closed cycle rebreathing apparatus and utilizes a blower for circulation.

The MPRS consists of two modules: a rebreather module and a chiller module. The rebreather module is a portable unit 8-1/2 inch x 13 inch x 26 inch and weighs 48 pounds fully charged. It contains the O₂ supply, CO₂ removal canister, blower, battery power supply and an O₂ monitor. The rebreather module maintains the MPS at one-half to one inch water gauge static pressure above ambient by means of the O₂ supply. The chiller module is not portable, being fixed to a mining machine. The chiller module is a mechanical

refrigeration unit and is 12 inch x 20-1/2 inch x 26 inch and weighs approximately 125 pounds. The miner in the MPS is joined with the rebreather module and chiller module by 1 inch flexible tethers. Connections between units are made by 1 inch disconnects.

Figure 1 shows the flow schematic for the MPRS.

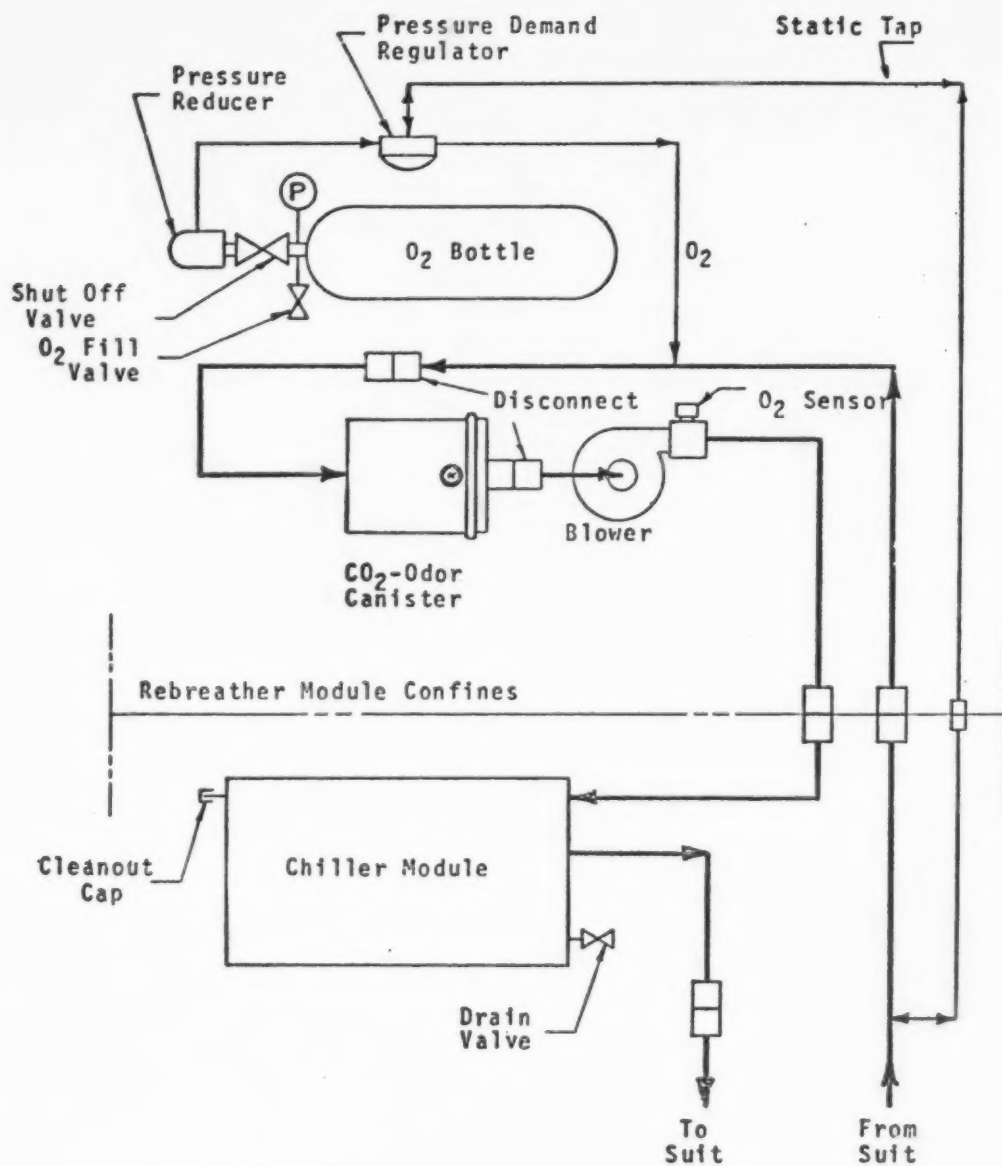


FIGURE 1 - FLOW SCHEMATIC FOR MPRS UNIT

REBREATHER MODULE DESCRIPTION

The servicing of the rebreather module is very important and trained personnel are required to insure integrity and proper operation. Suitable check-off procedures must be followed to assure safe operating conditions for personnel using the MPRS.

O₂ Supply

The O₂ supply system consists of an O₂ bottle, shut-off valve, pressure gauge, fill valve, pressure reducing regulator and a pressure demand regulator.

The O₂ bottle is a steel bottle approximately 4-1/4 inch diameter x 16-3/4 inch long and weighs about 8-1/2 pounds. The free volume is 170 cubic inches. The O₂ storage capacity is 13-1/2 ft³ when charged to 2000 psig. The O₂ bottle conforms to ICC-3AA-2015 regulations.

A brass shut-off valve is threaded into the 1/2 inch NPT female port on the O₂ bottle. The other end of the shut off valve is equipped with a CGA fitting for connection with the pressure reducing regulator. The valve is equipped with two 1/8 inch NPT female ports, upstream of the valve

seat for connecting a 0-3000 psig O₂ pressure gauge and a fill valve. The fill valve permits charging the bottle with O₂ while in the rebreather module and with the shut-off valve turned off. A rupture disc (pressure setting, 3200 psig) on the shut-off valve is provided to protect against bottle overpressure.

A pressure reducing regulator is attached to the shut-off valve by means of the CGA fitting discussed above. The pressure reducing regulator reduces the bottle pressure to 80-85 psig and feeds O₂ to a low pressure demand regulator. The pressure reducing regulator is of brass construction. An adjustment nut is provided in the dome of the pressure reducing regulator to change output pressure if desired (output pressure range of the regulator is adjustable from 50-90 psig).

O₂ flows from the pressure reducing regulator to the low pressure demand regulator at 80-85 psig. The pressure demand regulator is a spring-loaded regulator which reduces the O₂ supply pressure from 80-85 psig to a lower pressure (in inches of water). The desired pressure in the MPS is 1/2 - 1 inch water gauge pressure. The pressure demand regulator was modified to maintain the suit at 1/2 inch water gauge pressure by means of a static tube located in

the return tether at the suit exit disconnect (yellow coded). The static tube regulated the O₂ flow from the pressure demand regulator into the rebreather by sensing the pressure at the suit outlet and controls suit inflation at 1/2 inch water gauge pressure.

Carbon Dioxide-Odor Removing Canister

The carbon dioxide-odor canister is an "O" ring flanged, Epoxy-coated aluminum container with a brass liner; approximately 6 inches diameter x 7 inches long with adjoining 1 inch quick disconnects. The canister is removable from the rebreather module by means of the quick disconnects so that the canister can be serviced. A window is provided in the canister to show depletion of the baralyme CO₂ sorbent by a color change from pink to blue. The canister is charged with 4-1/4 pounds 4-8 mesh pink indicating baralyme. The Purafil can be used again and again having days of useful life; the Purafil granules should be replaced approximately every 40 hours; the baralyme should be replaced after each 4 hour use or after each exercise to keep fresh granules in the canister. The weight of the charged carbon dioxide odor canister is about 7.8 pounds.

Servicing the carbon dioxide-odor canister is discussed in the Maintenance Section of the manual.

Blower

The air circulation blower is a centrifugal type fan. It delivers 15 cfm air at 13 inch water gauge static head. The blower has DC motor drive and is equipped with a rectifier so that it can operate on 24 volts AC as well as DC power supply provided by batteries. The blower weighs 5.6 pounds. An inlet disconnect mates with the carbon dioxide-odor removing canister. The blower discharge is "O" ring flanged with piping to which is mounted the O₂ sensor.

Battery Pack

The rebreather module is equipped with a battery pack to provide power when transit is made with the rebreather module from a rest station to the mining equipment. Six rechargeable Silver-Zinc type batteries are used. This battery pack supplies 7 amp/hr (5 amp/hr guaranteed) at 24 nominal voltage output.

The six batteries are wired in series to supply 24 volt DC power output. These batteries are arranged as 2 sets of 3 batteries each for recharging purposes. Each set of 3 batteries in the battery pack case recharge the batteries from the 24 volt AC power supplied to the rebreather

module. It requires approximately 4 hours to recharge the batteries after 15 minutes operation when the rebreather module is operated from the battery supply, or 16 minutes of recharging per one minute of use. The battery pack with the 6 batteries, 2 battery rechargers, fuses, lights, relay and tilt switch, packaged as a module weighs approximately 5.6 pounds. This pack is removable from the cabinet being fixed to the end panel of the rebreather module cabinet.

The batteries will not recharge in a position other than vertical since electrolyte leakage may occur. Therefore, a tilt switch is provided on the battery pack to interrupt current charge flow if the rebreather module is positioned so that the batteries are not nearly vertical (approximately 45° from vertical stops charging). The battery chargers are fused (0.3 amp) and green indicating lights are on when the batteries are being charged. When fully charged, the lights are off. The green indicating battery charger lights will also go off if the tilt switch is off.

Power Supply

A fixed 24 volt AC, 250 volt-ampere transformer is used to provide power to the rebreather module. This transformer is located on the chiller module. The transformer primary is

115 volt AC, single phase, 50-60 HZ. A fused power cord extends from the transformer secondary and a connector plug mates with the receptacle on the rebreather module case.

Important: Only a 24 volt AC power supply should ever be connected with the rebreather module. Do Not Exceed 24 Volts.

The power supply requirements for the MPRS are listed below. Less than 1 HP is required. Power source for both the rebreather module and chiller module is 115 volt AC, 1 Ph, 50-60 HZ. A single plug three prong 115 volt plug provides power to the power distribution box in the chiller unit. A power cord extends from the distribution box to the primary of the transformer. A wire harness with connector plug extends from the 24 volt AC secondary of the transformer and mates with the receptacle on the rebreather module.

Rebreather Module

<u>Part</u>	<u>Power, watts</u>
Blower	90-120 watts
Battery Charger	110 (est)
Lights, etc.	16
Transformer Loss (est)	20
Sub-Total	<u>10</u>
	156 watts

Chiller Module

Refrigerant Compressor	1/3 HP, 115V AC	290
Condenser Fan,	1.7 amp	<u>196</u>
Total Power (approx.)	MPRS unit	642 watts

Control Panel

A control panel is located on the left front side of the rebreather module. This panel has a switch to start the blower. A white light under the switch shows that the unit is operating on AC power; this light is off when the unit is operating on the batteries.

A red light is provided on the control panel to indicate low O₂ concentration. This light will go on when O₂ concentration is below 18%. The O₂ monitor on the panel gives the O₂ concentration in the rebreather module. The O₂ monitor is powered by its own 5.6 volt mercury cell. A jack receptacle on the O₂ monitor connects via a cable to the remote O₂ sensor on the rebreather module piping at the blower discharge. The battery and O₂ sensor have about a 1 year service life and require replacement each year.

Other lights on the control panel are a green and amber light which indicated flow through the canister. To guard

against the possibility of an empty canister being used, the amber light denotes this by low pressure drop. The green light is to show higher pressure drop when the canister is filled.

Although lights are provided to show canister fill condition, the canister window can show whether the canister is filled. See Operation Section on Carbon Dioxide-Odor Removing Canister.

CHILLER MODULE DESCRIPTION

The chiller module provides cool air to the suited miner. Air flow from the rebreather module passes into the chiller module to remove latent (condensed water) and sensible heat and then back to the suited miner.

The chiller module contains 1/3 HP Freon 12 refrigeration unit with an adjustable refrigerant control valve. The control valve regulates the temperature at which the refrigerant passes across the outside of the finned, copper, cooler tubes to remove heat and condense water. The cooler is a copper tank, 12 inch diameter x 10 inch high. A drain is provided on the bottom of the cooler to remove condensed water. A port is provided on the top of the cooler to wash it out to make it antiseptic for the next use.

Temperature control is provided automatically by the refrigeration compressor going on-off depending upon the expansion valve settings and cooler heat duty load.

Power supply to the chiller module is 115 volt, single phase, 60 HZ AC. The weight of the chiller module is approximately 125 pounds and dimensions are 12 inches high x 26 inches long x 20 inches wide. Materials of construction are copper coil, steel and transite.

The fixed voltage (24V AC) power transformer for the rebreather module is mounted on the chiller module. The power supply to the transformer is 115 volt AC, single phase, 60 HZ.

Figure 2 is a flow schematic of the module. Warm air from the suit enters the cooler tank, which contains the refrigerant coils. Some moisture is removed and the air cooled for return to the suit.

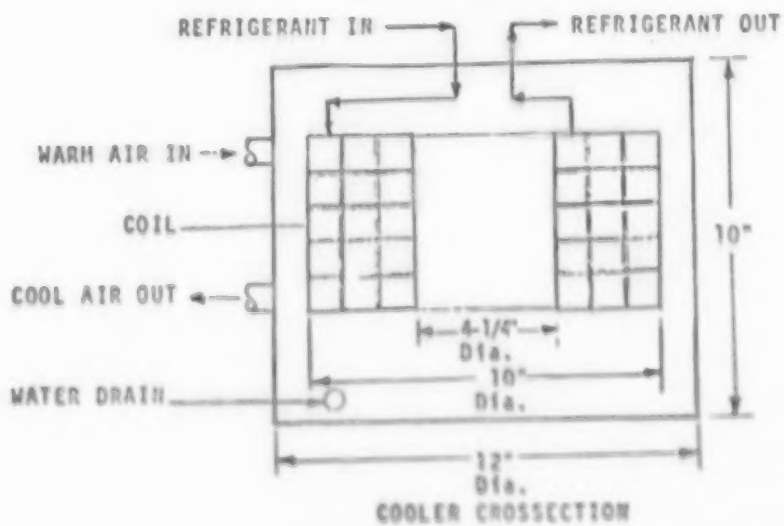
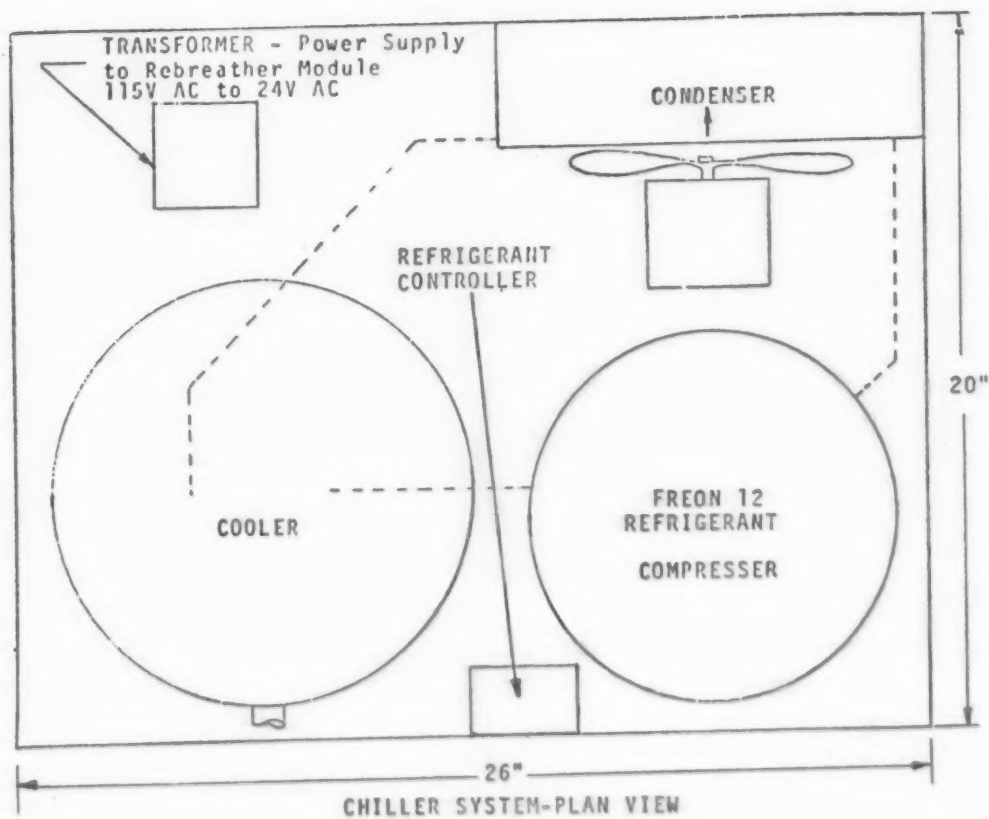


Figure 2 - CHILLER FLOW SCHEMATIC

ELECTRICAL SCHEMATIC

The electrical schematic for the MPRS is shown in Figure 3.

Two relays are used so that the unit can operate on either AC power or its own self-contained batteries. Relay 1 has four contacts and is located on the battery pack module. When AC power is provided to the rebreather module, as denoted by the white light, relay 1 closes contacts so that the battery chargers can recharge the batteries. If the batteries are not in a vertical position, the tilt switch breaks the circuit. Relay 1 also opens the circuit from the battery supply when AC power is supplied. Relay 2 closes when AC power is supplied to MPRS. If no AC power is supplied the contacts remain open, allowing blower and control circuits to operate from battery power. Relay 2 is a double pole, double throw, 10 amp control 24 volt type.

A third relay, relay 3, is used in conjunction with the O₂ analyzer to actuate low O₂ concentration alarms. The coil of relay 3 is energized by the O₂ analyzer battery but power through relay 3 contacts comes either from the AC or DC supply. When the AC power plug is disconnected from the rebreather module, the DC power supply runs the system.

Never apply voltage greater than 24 volts AC to the re-breather module since higher voltage will damage the electrical components.

The chiller is operated by 115 volts from the primary power source from which the entire unit operates. Power is distributed to the compressor which in turn is controlled by an adjustable pressure switch to regulate refrigeration temperature. There are two (2) safety interlocks to protect the compressor: high pressure from pressure switch malfunction and low pressure from loss of refrigerant.

OPERATION

The MPRS consists of the rebreather module, a chiller module and a gas-tight mine personnel suit (MPS). Each miner in his MPS has a rebreather module and a chiller module. These modules are interconnected by means of one-inch flexible tethers (hoses). While traveling to the mining machine, the miner uses only the rebreather module; the chiller module being permanently fixed to the particular mining machine to which he has been assigned.

Before donning his suit, checks should be made to assure that the equipment is properly operating and has been serviced properly. This check-off list includes:

- Fresh charge of chemicals in the carbon dioxide-odor removing canister - rebreather module.
- Fully charged O₂ bottle (1800 psig) - rebreather module.
- O₂ analyzer is working and reads 21% O₂ when air is flowed through the system. O₂ analyzer switch must be on to get reading.
- Fully charged batteries - rebreather module.

- Blower is operating - rebreather module.
- Condensate (water) is drained and water flush (cleaning) performed - chiller module cooler. Drain valve is closed.
- Pressure check to assure no loose fittings, tether cuts, or large leaks from system - rebreather module and chiller module.

O₂ monitoring is provided in the MPRS but no provision is made for CO₂ monitoring. The only indication for CO₂ monitoring is the window on the carbon dioxide-odor removing canister: a change from pink to blue denotes exhaustion of the baralyme CO₂ absorbing granules.

The sequence is for the miner to first hook-up and test equipment prior to entering mine, then enter and portage to the work station. The miner, after putting on his suit, makes tether connections with the rebreather module and connects the static line from tether to rebreather module.

After making tether connections, the flow switch must be turned on to circulate air through the suit. The helmet

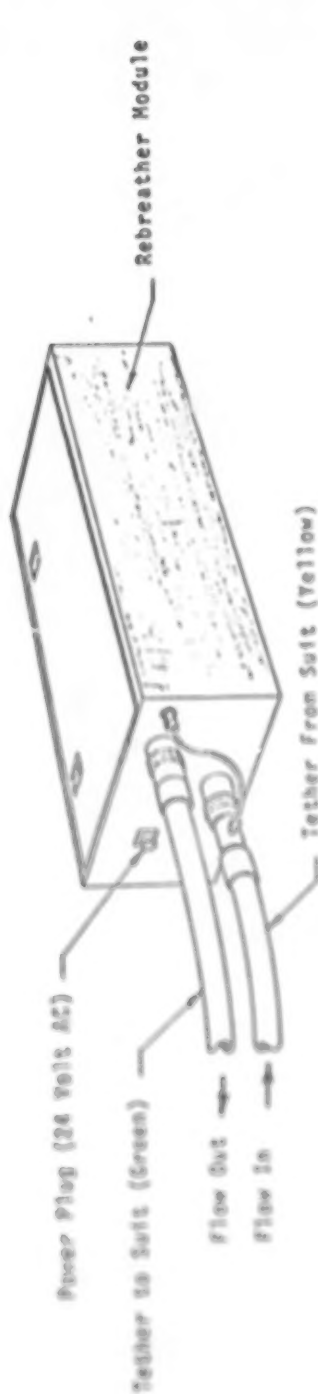
is now put on to close the system and O_2 provided by opening the valve on the O_2 bottle which starts O_2 flow into the rebreather module.

Important: Never open oxygen bottle valve until tether and static line are connected. If connections are not made, demand regulator will feed O_2 and cause over-pressurization in rebreather module.

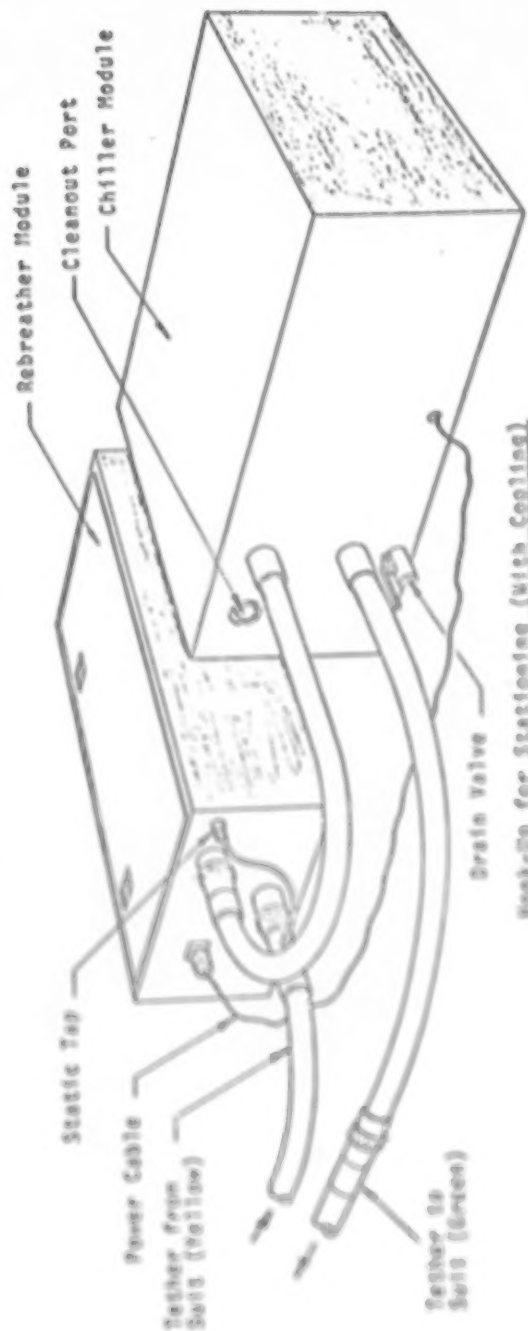
Turn the O_2 analyzer on to get O_2 concentration in the system.

Note: Because of the large free volume in the MPS, filling the suit with O_2 will cause initially high O_2 concentrations. Filling the suit with air will prevent the initially high O_2 concentrations which occur with O_2 filling. Filling with air can be accomplished by use of the blower and drawing air into system from blower suction through the inlet tether.

Portaging and stationing tether operations would proceed as discussed. Figure 4 illustrates tether connections for these operations.



Hook-Up for Portaging (No Cooling)



Hook-Up for Stationing (With Cooling)

FIGURE 4 TETHER CONNECTIONS FOR MPBS

Tether Hook-Up Portaging

The rebreather module is designed with a carrying handle so that the miner can be self-contained when going from a rest station to the work station. This is to be no more than a 15 minute period. During this period, the miner is supplied O_2 and CO_2 is being removed. The blower operates on battery power. There is no cooling while in portage since the chiller is permanently mounted to the mining machine.

The portaging hook-up is made prior to entering the mine mouth personnel lock, the tether from the suit, yellow coded, is attached to the rebreather inlet and the green coded tether to the outlet of the rebreather module. The quick disconnect valves are installed so that it is impossible to make the wrong connection. When portaging, air is circulated by the blower powered by the battery supply in the rebreather station.

Tether Hook-Up Stationing

When the miner has arrived at his work station, he mounts the rebreather module on the mining equipment and proceeds as follows:

- Go on AC power supply and off battery power. This is done by connecting the power plug extending from the chiller module to the rebreather module. The chiller module contains a 24 volt AC power supply transformer and the chiller unit is powered from a 115 volt AC power plug. This power plug is connected with a 115 volt power supply on the mining machine. This should be done first to conserve battery power and being recharging the batteries. When the power plug is attached, the DC power from the batteries is automatically cut out but the blower automatically continues to operate from the AC power supply.
- Disconnect the green coded tether from the rebreather module outlet, joining it now to the tether extending from the chiller module (air from chiller). When the disconnect is removed, flow stops since the disconnects are valved and shut off when disconnected. The valved disconnects are intended to prevent drawing outside gas into the system. The yellow tether disconnect remains fixed as it was during portaging, and is not removed from the rebreather.

Note: The yellow tether is never removed in the mine.

Next, the tether from the chiller (air to chiller) is connected with the disconnect on the rebreather module from which just previously the green coded tether was disconnected. Upon making these connections, flow again will be sensed and cool air obtained from the chiller module. The hook-up for station operation is now complete.

Note: As long as the yellow coded tether disconnect has not been removed from the rebreather module, hook-up to the chiller module can be made without mixup since the disconnects are indexed and can go together only one way.

The above operations are reversed when going from the work station to the rest station. The tethers are disconnected from the chiller module. Join the green coded tether extending from the suit back to the rebreather module outlet disconnect. During the disconnect, flow temporarily stops until reconnection is made. The power plug is next disconnected to free the rebreather for transit back to the rest station.

Blower

No speed control is provided. The blower continues to operate continuously as long as the blower switch is on. Switching the AC power supply plug on or off does not interrupt flow. Operating the blower on DC power for long periods should be avoided to prevent running down the batteries. The system can be operated on battery supply for approximately one hour without recharge.

The volume of flow from the blower is dependent upon system pressure drop. Flow through the system with two 10 feet long 1 inch tethers will be greater than if two 20 feet long 1 inch tethers are used since the longer tethers will increase system pressure drop.

The blower performance curve is shown in Figure 5.

Carbon Dioxide-Odor Removing Canister

There is no monitoring of CO₂ concentration. The indication of a CO₂ breakthrough is observed in the window in the baralyme canister. The pink indication baralyme changes to blue when approaching exhaustion. The baralyme in the canister should be replaced after each work period or four

Blower Performance
MPRS Unit

Globe Ind. P/N 19A2336
Centrifugal Type

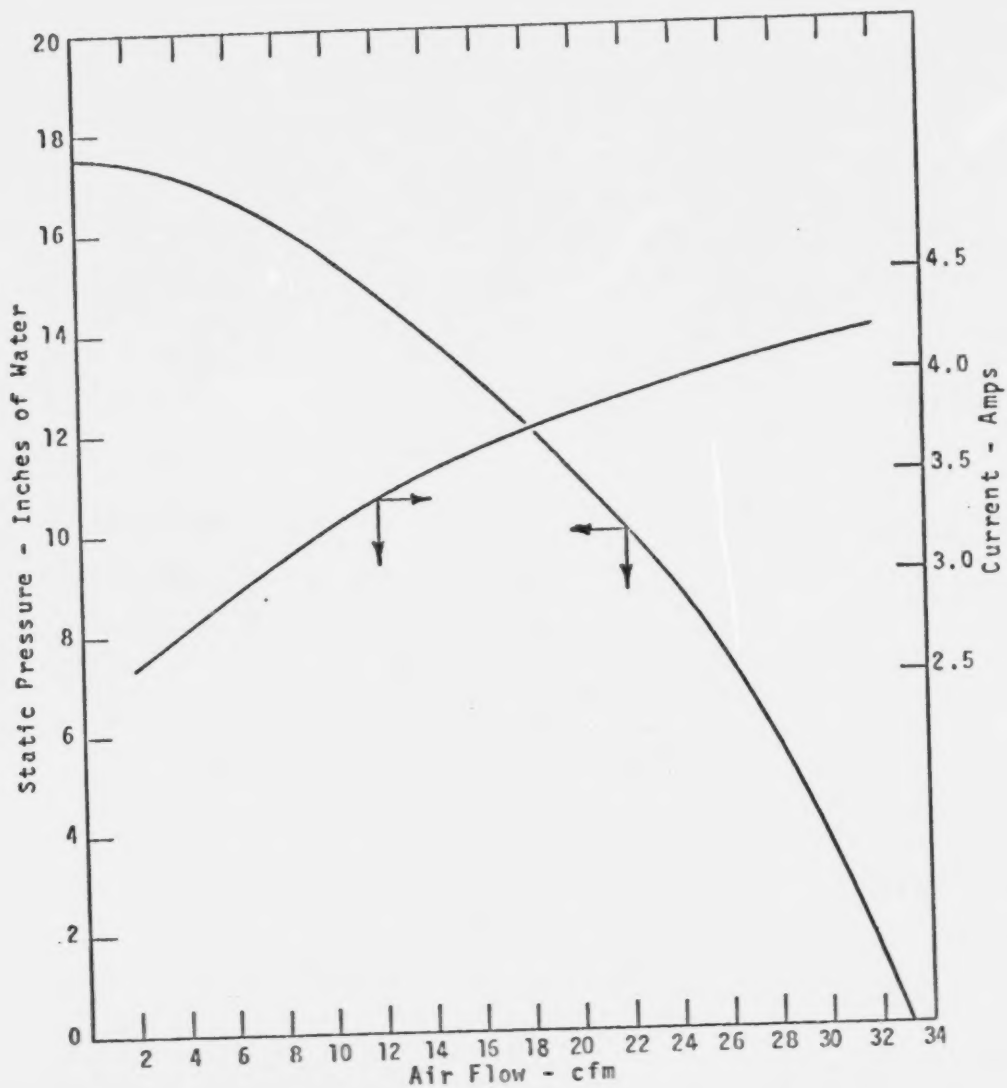


Figure 5 - Blower Performance Curve

hour period. The operator should periodically view the window for color change which can be viewed by raising the hinged lid on the top of the rebreather module.

Note: The pink to blue change occurs but if the granules are not removed from the canister after use. The pink color returns but not as vividly as when the granules are fresh. The charged canister weighs approximately 7.7 pounds when charged with the chemical granules. Weighing the canister and viewing the windows are means to show whether the canister is filled. Since the baralyme absorbs CO_2 but liberates water, no appreciable weight change occurs before and after using the canister and cannot be used to show the state of the baralyme.

O_2 Supply, Monitoring, and Suit Pressure Control

The O_2 bottle pressure gauge shows available supply pressure. If pressure reaches the yellow mark, the operator should leave the mine and have the bottle recharged to 1800 psig. This pressure difference provides approximately 11.5 ft^3 O_2 .

A low level O₂ concentration is detected by the red light in the control panel. This light goes on when O₂ concentration is approximately 18%. The O₂ analyzer meter gives the O₂ concentration in the system. An audible signal is also provided by a Sonalert in the O₂ analyzer. The O₂ analyzer switch must be on to get O₂ concentration readings and to actuate the low O₂ alarms. To conserve the O₂ analyzer battery, keep the switch off when the MPRS is not in use.

The O₂ supply from the pressure demand regulator maintains the suit pressure at 1/2 inch water gauge pressure. Because of varying static pressures in the system with the blower, the pressure demand regulator was modified with a static pressure tap to control O₂ flow from the valve to the regulator. The suit pressure is maintained at 1/2 inch water gauge pressure by a static tube extending from the underside of the pressure demand regulator to the outlet suit tether. This tube is located inside the 1 inch flexible tube tether and terminates at the 70° port (yellow coded) which mates with the suit disconnect. Static pressure is sensed by the tube and applies force on the diaphragm in the regulator. When static pressure is satisfied, the diaphragm is forced up which closes off O₂ flow into the rebreather.

Battery Charging

When the miner is suited and at the work station, the batteries will recharge automatically when the 24 volt AC power plug is connected with the rebreather module. AC power supply is indicated by the white light on the front panel. When the two green lights on the battery pack are on, the batteries are recharging. When the lights are off, the batteries are fully charged. The rebreather module must be positioned with lid up in order to recharge batteries.

When the rebreather is off the mining machine, the batteries can be recharged only from a 24 volt source. This requires a separate transformer at the recharging station. Such a transformer is built into the chiller unit, but must be supplied separately elsewhere.

Shutdown Procedures

To shut down, first shut off the O₂ bottle valve; this prevents wasting O₂. Next disconnect tether from rebreather and from suit. Remove helmet. Shut off blower switch. Turn O₂ analyzer switch off to conserve O₂ analyzer battery.

MAINTENANCE

Carbon Dioxide-Odor Removing Canister

The CO₂-odor canister is held into the rebreather module by disconnect fittings and a swing clamp. To remove the canister, the nut on the clamp is loosened so that the clamp can be swung free of the piping. Release the disconnects and remove the canister from the rebreather module. Remove the lid and the spring-loaded pressure plate assembly. The Purafil bag is next removed and retained for the next use of the unit. The spent baralyme granules are dumped from the canister and discarded.

A fixture to hold the canister for servicing is desirable. Be careful not to damage the canister flanges. To refurbish the canister, see Figure 6 and proceed as follows:

- Insert the fiberglass cloth disc into the canister. If it has become dislodged or worn, it should be replaced. This serves as an inlet filter.
- Add pink indicating 4-8 mesh baralyme in 1/3 increments. Shake can after each addition to pack down baralyme. Fill the canister as full as possible.

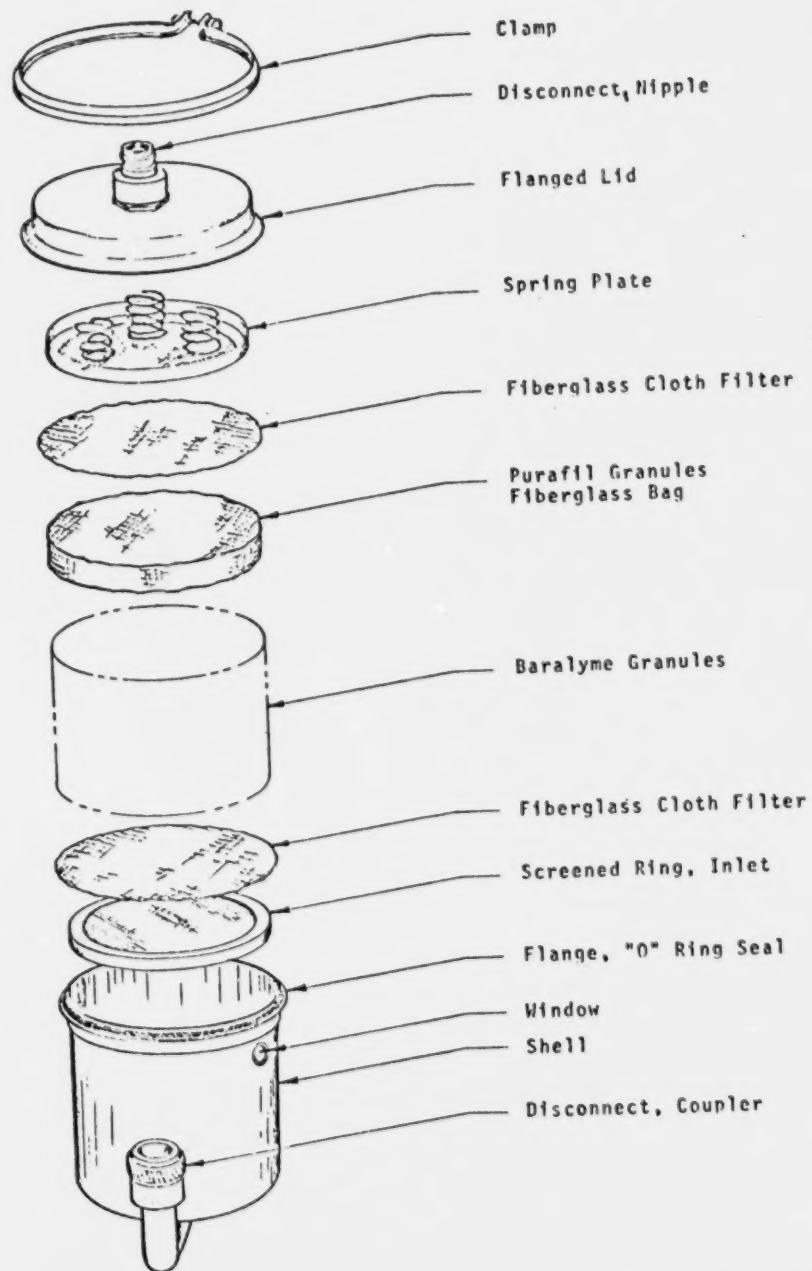


Figure 6 Carbon Dioxide-Odor Removal Canister - Telescopic View

MAINTENANCE

Carbon Dioxide-Odor Removing Canister

The CO₂-odor canister is held into the rebreather module by disconnect fittings and a swing clamp. To remove the canister, the nut on the clamp is loosened so that the clamp can be swung free of the piping. Release the disconnects and remove the canister from the rebreather module. Remove the lid and the spring-loaded pressure plate assembly. The Purafil bag is next removed and retained for the next use of the unit. The spent baralyme granules are dumped from the canister and discarded.

A fixture to hold the canister for servicing is desirable. Be careful not to damage the canister flanges. To refurbish the canister, see Figure 6 and proceed as follows:

- Insert the fiberglass cloth disc into the canister. If it has become dislodged or worn, it should be replaced. This serves as an inlet filter.
- Add pink indicating 4-8 mesh baralyme in 1/3 increments. Shake can after each addition to pack down baralyme. Fill the canister as full as possible.

- Insert the activated Purafil bag into the canister on top of the baralyme granules, pressing the bag against the canister wall and thereby containing the baralyme granules. Next insert the fiberglass cloth disc to provide additional outlet filtering.
- Make sure the "O" ring is installed on the canister. Next the spring-loaded pressure plate assembly is inserted, the screened ring end against the Purafil bag and the springs extending up.
- The lid is next placed over the canister shell end with the rubber "O" ring engaged on the flanges. Keep flanges and "O" ring clean to assure proper seal. Hold the lid down and slip the ring joint bolted clamp over the canister flanges. Match the clamp and canister index marks. Secure the bolt and fasten the clamp to the lid and canister shell.

Note: The rebreather module must have tight connections to prevent leakage into or out of the system.

- The canister should be pressure tested to make certain that the canister is leak free. Put a cork with an air line fitting into the disconnect on the lid. Put a blank

cork in the disconnect on the other end. Apply oil free air or nitrogen at 10-15 in. water gauge water pressure to the canister and immerse in water. Check to see if any air bubbles are escaping from the "O" ring sealed flanges and other fittings in the canister.

- To install the canister into the rebreather module be sure that the flex hose assembly is above the O₂ bottle and accessible to reconnect with the canister. Pull back the quick disconnect coupling on the blower so that the quick disconnect nipple on the canister can be partially engaged inside the quick disconnect coupling on the blower. Orient the canister window up (toward the rebreather module lid) and the piping from the canister to mate with the flex-hose assembly. Next mate the coupling disconnect from the canister with the nipple on the flex hose assembly. Secure the canister in the rebreather module by tightening the swing clamp bolt.

Oxygen Bottle

The O₂ bottle is recharged inside the rebreather module. Fittings are designed and arranged so this can be accomplished without removing the O₂ bottle.

ICC regulations require that the O₂ bottle be hydrostatic tested every five (5) years. The O₂ bottle is stamp coded to identify the last time it was tested. This is done by the manufacturer of the bottle whose name appears on the bottle. These inspection dates should be observed strictly to assure that these inspections are conducted.

Recharging the O₂ bottle must be done in a clean room, free of oil, grease, coal dust and other combustibles, and specifically for this purpose.

When charging the O₂ bottle, be sure that all fittings are free of grease, oil, coal dust and other combustibles.

Clean housekeeping must be followed to assure safe conditions with high pressure O₂.

O₂ Bottle Charging

The O₂ bottle should be recharged when pressure is at the yellow line. Avoid letting the bottle pressure fall any lower or to zero pressure since maintaining a positive pressure on the bottle at all times minimizes condensate collection in the bottle.

Proceed to fill the O₂ bottle by having the O₂ bottle valve off. A fill valve with a yellow dust cover is provided on the shut off valve and upstream of the valve seat. An O₂ pressure gauge is also located upstream of the shut off valve to show O₂ bottle pressure at all times. NEVER TRY TO REMOVE THE FILL VALVE OR THE PRESSURE GAUGE WHEN THE BOTTLE IS UNDER PRESSURE. This must only be done when the pressure is zero in the bottle. Remove the yellow dust cover cap which is screwed to the fill valve. Screw the brass high pressure hose fitting to the fill valve from which the dust cover was removed. The high pressure hose fittings has a 1/8 in. NPT female fitting on the end opposite which mates with the fill valve. This 1/8 in. NPT female end of the hose fitting can be fitted to an O₂ manifold-bottle cascade system set up in the designated O₂ servicing area. The cascade O₂ bottle recharge system is not part of the MPRS.

During filling, the O₂ bottle becomes warm by the O₂ compressing into the bottle. The manifold from the O₂ bottles cools from expansion, the O₂ pressure gauge shows bottle pressure. The O₂ bottle should be filled to 1800-2000 psig. Do not exceed 2000 psig. Because the bottle becomes warm, a slight drop in bottle pressure will be observed when the bottle cools back to room temperature.

Removing O₂ Bottle

If the bottle must be removed from the rebreather module for required hydrostatic test or other purposes, proceed as follows:

- Remove left side panel of the rebreather module to which is mounted the battery pack. This is accomplished by removing the screws holding this panel to the rebreather frame.
- Disconnect the power plug from the battery pack to free it from the rebreather.
- Remove the side with the battery pack attached leaving the left side open to remove the bottle.
- Disconnect the tube fitting on the pressure reducing regulator.
- Release the two clamps holding the O₂ bottle in the cabinet. The O₂ bottle with valve, gauge, and pressure reducer attached can now be slid out of the case.

O₂ Analyzer

The O₂ analyzer should be calibrated daily to assure accuracy. Ambient air can be used for a calibration gas. Turn the blower on and move air through the rebreather module. Be sure that mating disconnects are engaged so that air can pass into and out of the rebreather. A reading of 21% should be observed. Further description of the O₂ analyzer and adjustments are given in the brochure in the Appendix of this manual.

To check if the alarms are working, put nitrogen into the rebreather module piping which will decrease the O₂ percentage. Do this by using the suit tethers, disconnected from the suit, but connected to the rebreather. (This gives an open circuit through the system.) Bleed cylinder nitrogen into the yellow disconnectors. This will flow through the system and flush out oxygen. The red light and sonalert will go on at approximately 18%. The inlet and outlet disconnects should be closed (no tether connections).

To perform these checks, the O₂ analyzer switch must be on. The life of the battery and remote O₂ sensor is approximately one (1) year. These should be replaced after one (1) year service time. Replacement of the battery requires removing the O₂ analyzer from the rebreather module control panel.

The oxygen sensor is screwed into a block off the blower discharge. To replace this unit, disconnect the electrical jack and then unscrew the sensor. Rewire the new sensor to the old jack. Screw in the new sensor. Do not use a wrench; hand tighten only, or the sensor will be ruined! Make certain the gasket between the old sensor and piping is reused to prevent leakage from the system.

Blower

The expected life on the blower is 1000 hours. This life is primarily predicated on the brush life of the 24 volt DC motor. It is impractical to put brush wear indicators on a miniature blower because of the small brush size; larger motors can be so equipped. Periodic checks on blower static head might be used to detect blower performance change. A built-in rectifier permits operation on a 24 volt AC power supply. Any rebuilding required on the blower of an electrical nature should be performed by the blower manufacturer.

The blower is bolted to the rebreather module case by four bolts and nuts. The inlet disconnect joins it with the canister as discussed previously. The outlet piping of the

blower is flanged together by a worm screw clamp. This flange is "O" ring sealed. A mating electrical connector on the base of the blower is removed to complete the release of the blower from the rebreather module case.

Battery Pack Module

The battery output is fused. (The battery chargers are also fused.) If no power is available, check the battery fuse first.

If there is an indication that the batteries are not charging, check the fuse. The indicating lights can also be checked to determine if they are burned out. Beyond these routine maintenance checks on fuses, the module should be returned to MSAR for further check.

Panel Lights

Panel lights can be replaced from the front of the control panel. Remove the threaded lens covers for access to the bulbs. The bulbs are pinned and are removed by pulling out.

Chiller Module

The chiller module contains a 1/3 HP refrigeration unit and cooler. A power supply transformer to supply power to the rebreather module is also located in the chiller module. Water will condense in the cooler and a drain valve (ball type valve - 90° turn opens and closes) is provided to remove condensed water. The cooler tank, 12 inch diameter x 10 inch high can store up to 10 pounds of water condensed from the breathing circuit. This should be drained after every eight hours of use.

The refrigerant evaporation temperature is adjustable by means of a controller on the unit. These have been set to provide approximately 30-40°F refrigerant evaporation temperature. No icing occurs at these settings. Lowering the temperature may cause icing and is not recommended since this could cause flow obstruction. The refrigerant evaporation temperature has been found comfortable in tests made with system.

The power supply transformer should require no servicing, only fuses may need replacement.

Tools and Servicing Items

No special tools are required for servicing. The following tools would be an adequate list:

Crescent wrench
Open end wrench
Pipe wrench

Screw drivers
Pliers
Fuse puller

Items to assist servicing include:

Weighing scale

Low pressure air supply (10-15 inch water gauge pressure)

Multi-test electrical meter

Fresh water supply

Cascade O₂ manifold and O₂ supply bottles

Nitrogen gas

TROUBLE SHOOTING

<u>Trouble</u>	<u>Cause</u>	<u>Remedy</u>
No flow, no power	Blower switch not on	Turn on blower switch
No flow, no power	Fuses blown	Check for shorts
No flow, no power	Batteries discharged	Recharge batteries (or) engage AC power plug
No flow, power on	Tethers not connected	Connect tethers
Low oxygen	O ₂ bottle valve off	Open O ₂ bottle valve
	O ₂ bottle empty	Fill O ₂ bottle
	Pressure control not correct	Service control regulator
Suit deflated	Regulator	Control regulator
Suit deflated O ₂ OK	Leak	Check system for leaks pressure side. Green coded tether. Repair leaks.
Suit over-inflated O ₂ OK	Leak	Check system for suction. Yellow coded tether. Repair leaks.
Batteries not charging	Batteries not in vertical position	Make sure lid side up, as per marking
Batteries not charging	Fuse blown	Position fuse

No cooling	Tethers not connected to chiller	Connect tethers to chiller
No cooling	Chiller not working	Connect power plug
Excessive odors	Spent Purafil	Replace Purafil
Excessive odors	Condensate tank	Flush and sanitize chiller unit

PARTS LIST

Blower 1 ea.	Globe Industries Div. of TRW Globe Model No. 19A2336 modified with sealed cover to prevent air leakage. Unit equipped with rectifier to permit AC usage
DP Switch	Aircraft Porous Media Co. Part No. MD 203 Car 33, 1 to 4 inch W. G. adjustable setting Deltadyne Pressure Switch
O ₂ Bottle 1 ea.	MSA Co. Part No. 86539, 14 ft ³ capacity steel bottle
Valve, Shut off for O ₂ bottle 1 ea.	MSA Co. Part No. 83760, modified with extra tap for direct O ₂ filling
O ₂ Pressure gauge 1 ea.	MSA Co. Part No. 55382, Gauge O ₂ Pressure 0-3000 psig range
O ₂ Fill Valve Components	Dill Valve Division, Eaton, Yale, Towne, Inc. Dill Part No. SK20420 Tank Valve with 202-vv Core Dill Part No. SK2427 Dust Cap Dill Part No. SK2043-C Hi Pressure Hose Coupling
Regulator, Pres- sure reducing	Hammon Precision Equipment Company Part No. 603-30 Regulator Pressure Re- ducing Brass Body, factory set @ 50-90 psig equipped with over pressure safety set @ 115 psi. 1/8 inch NPT female outlet, CGA 543 Nipple and CGA 544 nut provided

Regulator, Pres-
sure controlling
1 ea.

MSA Co.
Part No. 89108 Pressure controlling
regulator with dome and spring,
modified with static tap

CO₂-Odor Canister
1 ea.

MSAR Corp.
Part No. SK1-267-1 shell, aluminum
Part No. SK1-268 Lid, aluminum
Parker Co.
Part No. 2-437 "O" ring, neoprene
Marmon Co.
Part No. 55001-600-S Clamp, stainless
steel

O₂ Analyzer
1 ea.

Biomarine Co.
Part No. OM322R continuous O₂ monitor
with alarm and remote sensor

Batteries
6 ea.

Yardney Electric Co.
Model No. LR3/5 Rechargeable Ag-Zn
4.5 volt DC, 7 amp-hr type, 1.47"
x 1.87" x 4" ea. cell

Battery Charger
2 ea.

Yardney Electric Co.
Model No. 10, 18 volt output
Two required - repackaged to fit into
battery pack

Transformer, Power
1 ea.

Allied Radio
Stock No. 705-0175
115 volt, 1 phase 50-60 HZ AC
24 volt, 250 volt amps

Relays
1 ea.

Relay No. 1 Potter Brumfield No.
KL17A24
Cadmium oxide contacts, "A" case.
Scott Electronics

1 ea.

Relay No. 2 Potter Brumfield
Type KRP 11AG
DP, DT, 10 amp contacts 24 volt AC coil

1 ea.

Relay No. 3 Cornell Dubilier
Part No. 603
SP, DT, 6 volt, 340 Ohm coil

Tilt Switch
1 ea.

American Relays, Electronic Division
Stock No. SMP1-4

Lights, Panel	Red-Sylvania No. 41, 24 volt, 0.073 amps Green-Sylvania No. 41, 24 volt, 0.073 amps Amber-Sylvania No. 934, 24 volts, 0.040 amps White-Sylvania No. 934, 24 volts, 0.040 amps
Flasher	KAY-LAB No. 2460, Macchi Corp.
Switch, Blower 1 ea.	Allied Radio Part No. 8500K9 MS 24523-22
Power Disconnects Rebreather Cabinet Power Supply Cable Battery Pack	Amphenol P/N1-67-02E14-63P Plug Connector P/N1-67-02E14-63S Socket Connector P/N1-67-02E12-7P Plug Connector P/N1-67-02E12-2S Socket Connector P/N10S1-03 Plug Connector
Blower Plug	
Tethers	Flexible Tubing Corp. 1 in. CMD Vac-U-Flex PVC hose, 9.6 ft. long with 1 in. CMD Vac-U-Flex PVC end cuffs bonding agent
Tether	Flexible Tubing Corp. 1 in. Type CMD Flexible hose 1 in. Type CMD Hose cuffs
Tether Adhesive	Flexible Tubing Corp. P/N PC-7040000
Disconnects	Anaptite Co. Part No. AVHN-16-16-F Quick disconnect Valved Nipple, 1 in. NPT female, aluminum Part No. AVHC-16-16-F Quick disconnect Valved Coupler, 1 in. NPT female, aluminum
Suit Connector, mating nipple	Air-Lock Inc. Dwg. No. 4223, 70° Port

Chiller Module	Air conditioning Unit Bendix-Westinghouse Model No. BRH-1A03 1/3 HP Refrigeration Unit, 115 volt AC, 1 phase 60 HZ Compressor Evaporator - 12 in. dia. x 10 in. high Shell, 3100 BTU/hr finned copper coil
Baralyme	National Cylinder Gas Co. McKees Rocks, Pa. Part No. 640503-63 25-2 lb cartons 4-8 mesh Pink indicating baralyme granules
Purafil	Marbon Chemical Co. 1/8 in. Purafil pellets
Pressure Gauge	0-1" WC Magnehelic Pressure Gate Dwyer Instruments, Pittsburgh, Pa.

SPARE PARTS

The following spare parts were provided:

Fiberglass bag (Purafil)

Fiberglass filters (CO₂-odor canister)

Springs, coil (pressure demand regulator)

Clamps

"O" rings (CO₂-odor canister) and blower outlet

Gaskets (O₂ sensor)

O₂ fill valve and fill adaptor fitting

Panel lights

APPENDIX

Oxygen Monitor

Batteries

BioMarine Industries

101 West Lancaster Avenue, Devon, Pennsylvania 19433 215/687-2806

Advanced Product Bulletin

OM 322

continuous oxygen monitor with alarms

The OM322 Hand-Held Monitor is designed for use where oxygen concentrations may drop low enough to endanger life, or rise high enough to cause hazards of chemical reaction, fire or explosion. The instrument is finding wide use in mining, public utility work, the chemical industry, petroleum refineries, breweries, food processing plants, marine cargo operations, vehicles and aircraft.

The OM322 Monitor from BioMarine Industries displays absolute oxygen concentration directly on a 0-40 scale. Audible alarms are triggered when oxygen level falls below a preselected oxygen concentration which may be too low to support life. The alarm can be pre set to sound if oxygen rises above preselected concentration where there could be danger of chemical reaction, fire or explosion.

Temperature compensation is automatic between 32° and 104°F. Calibration is carried out in a few seconds simply using room or outside air. Sensors are stable over long periods and never need any "recharging."

The OM322 Monitor uses a long lived, readily available 9V transistor battery. The alarm circuitry draws negligible current making battery replacement infrequent. No amplifier is needed for sensor cable runs to 1000 feet.

Dimensions:	2" x 2 1/2" x 5" (5.1 cm x 6.4 cm x 12.7 cm)
Net Weight:	18 oz.
Scale Reading:	0-40%
Response:	90% in less than 10 seconds
Accuracy:	±1% of full scale
Sensor Warranty:	180,000 hours or one year

BIOMARINE CONTINUOUS OXYGEN MONITOR OM322

GENERAL

The BioMarine oxygen monitor is easily portable and simple to operate. It provides a continuous direct reading of the level of oxygen present in any given environment. The instrument is fully temperature compensated over its operating range of 28°F to 104°F and is unaffected by relative humidity. An alarm is activated whenever oxygen level falls below a pre-selected limit (or goes above the pre-selected limit for model OM322H).

PREPARATION FOR USE

- Battery Check - Before using the instrument, press the battery check pushbutton switch. If the meter reading is below the green band, the batteries must be replaced.
- Check Calibration - The sensor is temperature compensated; it need not be calibrated at the temperature at which it is going to be used to insure a correct reading throughout the entire operating range. To calibrate the unit, expose the sensor (5) to a known concentration of oxygen. If fresh air (21% oxygen) is used for calibration, allow

the unit to be exposed to fresh air for two minutes, then set the meter (3) at 21% by rotating the calibration screw (4) with a screw driver until the meter registers 21%. If the unit is calibrated with any other oxygen concentration, an off-line adaptor (6) should be inserted into the sensor face (see technique detailed under "Sample Analysis"). After the sensor face has been exposed to the known concentration for two minutes, rotate the calibration screw until the meter registers the concentration of oxygen used for calibration.

- Alarm Clock - To check the level at which the OM322 alarms, slowly rotate the calibrate pot until the alarm is heard. Note the meter reading. If it is not the desired alarm point, see the maintenance section. Recalibrate the sensor.

OPERATION

Analysis

After calibration is completed, the instrument can be used in the following ways:

- Direct Exposure - When the sensor is placed in the atmosphere to be analyzed, the meter will show the percent of oxygen concentration in the atmosphere within one minute of exposure.
- Sample Analysis - Place the off-line adaptor (6) into the sensor face (5). Connect the inlet hose (7) to the gas source. The outlet (8) may be left open or vented to another enclosure. If the pressure in the gas source is not sufficient to draw the sample across the face of the sensor, a small pump at the exhaust outlet (8) is required.

HIGH HUMIDITY ATMOSPHERES

If the sensor is used in a high humidity atmosphere, it is advisable to ensure that moisture does not condense and pool on the sensor face. Water accumulation can be minimized by placing the sensor on its side so that any moisture will run off the face after condensation. A liquid film on the sensor face will give an incorrect reading.

HIGH ALTITUDE ATMOSPHERES

As altitude increases, the oxygen pressure in normal atmosphere decreases for a fixed percentage reading on the instrument. This should be allowed for when using this instrument at altitudes in excess of several thousand feet above sea level.

MAINTENANCE

The BMI OM322 has been designed to be maintenance free under most operating conditions; the unit should not require calibration checks more often than once a day. However, when a unit is operated under conditions of extreme temperature and humidity, it is advisable to perform a check every 8 hours.

When the sensor has been used with gases containing a high concentration of contaminant (e.g., nebulized drugs from medical equipment, carbon from gas furnaces), sensor face should be rinsed with clear water and dried with a clean, soft cloth after each use to remove deposits which may have accumulated.

When the meter reading can no longer be correctly adjusted during calibration, and the battery voltage is high enough,

it can be assumed that the functional life of the sensor has terminated and it should be replaced.

- Sensor Replacement - Unscrew the cable from its holder and screw in a new sensor. The BioMarine Oxygen sensor is a sealed unit and may not be repaired. Under no circumstances should an attempt be made to disassemble the sensor body as this would void the BMI Warranty.
- Battery Replacement - The OM322 draws very little current from the batteries when the alarm is not activated. Therefore battery replacement should be infrequent. If the battery check indicates that the batteries are low, remove the back of the instrument by removing two screws and check that the battery holder contacts are clean. If a deposit has built up, it may be removed with emory paper. If cleaning the terminals does not help, replace both batteries with RCA VS164 5.6 volt mercury cells or their equivalent.
- Alarm Adjustment - Remove the back of the case. Note that on the electronic circuit board there is a large red pot with both a screw driver slot and a knurled finger adjustment. Using the calibrate pot on the face of the instrument, set the meter to the desired alarm point. Rotate

the red pot on the circuit board until the alarm is activated. Recalibrate the instrument.

- Zero Check - With the instrument turned off, check the meter reading. If it is not a true zero, turn the light blue screw on the meter face until the reading is zero.

BATTERIES

INTRODUCTION

The LR 3/5 SILVERCEL battery consists of 3 semi-sealed silver-zinc cells. Silver (the positive electrode) and zinc (the negative electrode) are the active elements. The electrolyte is a strong solution of potassium hydroxide.

The battery is equipped with pressure relief valves which will open in case of accidental pressure build-up within the cell. After the pressure has been relieved, the valves will close. It should be noted that no pressure build-up is expected if the battery is handled in accordance with the recommended operating instructions.

CONDITION OF SHIPMENT

This battery is shipped in the formed, wet, charged, or formed, wet, discharged state (see paragraph 6).

STORAGE

Retention of capacity of a filled and charged battery can be improved by using temperatures lower than room temperature for storing the battery. These temperatures can be as low

as 0°F, with retention of capacity improving as the storage temperature is decreased.

CHARGING PROCEDURES

The battery should be charged in the upright position.

For optimum performance, charge the battery at the rate of 0.2 ampere maximum to the recommended end charging voltage of 5.90-6.00 volts. The voltage is to be measured across the battery terminals during charging.

NOTE: The recommended end charging voltage of semi-sealed SILVERCEL batteries must be strictly observed.

Charging above 6.00 volts will not add useful capacity but may decrease the cycle life of the battery.

DISCHARGE RATES

This battery is designed primarily for discharge at the 2-5 ampere rate. However, pulses of up to 15 amperes for short period duration are permissible.

STATE OF CHARGE

The fully charged IR 3/5 battery will have an open circuit voltage of 5.45 to 5.65 volts. After approximately 25 percent of the ampere hour capacity has been discharged, the open circuit voltage will drop to a lower value of about 4.8 volts and will continue to read this value until the capacity of the battery has been exhausted. The battery capacity is exhausted if the battery voltage at the 2 ampere discharge rate is less than 3.3 volts. If the open circuit voltage of the battery is less than 4.8 volts, the battery is not fully charged and may be given a further charge if more capacity is required.

APPENDIX C

OPERATING AND MAINTENANCE MANUAL

CAMBION MODEL TS 804-1003-01
DEHUMIDIFIER AIR EXCHANGER

GENERAL

The Cambion TS 804-1003 Dehumidifier Air Exchanger is specifically designed to be used in conjunction with a life support system for coal mining. It will cool and dehumidify 15 CFM of air passing through the inner chamber and discharge the resulting condensate into a closed container. A manual control, located on the power supply, allows the operator to adjust the performance of the unit in order to provide the most comfortable environment.

INSTALLATION

The TS 804-1003 may be mounted in any convenient location on the mining equipment as long as the following conditions are met:

1. Sufficient clearance from surrounding objects must be maintained in order to permit a good flow of cooling air (or other gases) through the heat sinks.

2. A protective grille or other device should be located above the cooling assembly in order to prevent damage from falling debris.
3. Both the power supply and cooling assembly should be shock-mounted in order to keep vibration to a minimum.

AIR CONNECTIONS

Two brass fittings are provided for the connection of air hoses to the cooling assembly. It should be noted that the air INLET is on the same end as the water discharge fitting and cable entrance.

A. Clamp Connections

If clamp-type connections are used on the air fittings, the only precaution to be observed is to avoid the use of excessive force when tightening the clamp.

B. Solder Connections

When making solder connections to the brass air fittings, it is necessary to completely remove the fittings from the assembly in order to avoid heat damage to the plastic

material to which they are attached. Removal of these fittings is accomplished by removing the four #4-40 screws and pulling the fitting off. Care should be taken to avoid damaging the rubber gasket.

When reattaching the fitting to the assembly, the rubber gasket and surrounding area should be sealed with Dow Corning clear "Silastic" 732 RTV Sealant. A small tube is supplied for resealing. The joint between the brass fitting and the plastic material should be checked for leaks and additional 732 RTV applied if necessary. Allow the sealant a minimum of one hour to cure.

WATER (DRAIN) CONNECTIONS

Connect a length of 1/4 O.D. copper tubing from the drain connection on the cooling assembly to the condensate collection container. The collection container should be located as near to the cooling unit as possible and must be lower than the cooling assembly to permit proper drainage. It is important to note that the collection container must be sealed to prevent leakage to or from the outside atmosphere.

ELECTRICAL CONNECTIONS

1. Connect the ten-pin male connector on the end of the six foot cable from the cooling assembly into the mating female socket on the power supply.
2. Connect a source of 250 volts DC to the remaining (male) connector on the power supply. The positive (+) side of the DC source connects to PIN B on the connector, and the negative (-) side connects to PIN A.

CAUTION

Failure to observe the correct polarity when making electrical connections will result in damage to the power supply.

OPERATING INSTRUCTIONS

1. Make necessary air, water, and electrical connections as specified in the preceding paragraphs.
2. Turn the adjustable control on the power supply to zero (0).

3. Place the toggle switch on the power supply in the up position. The red pilot lamp should light and the fans should operate.
4. Gradually turn the adjustable control clockwise to increase the level of cooling and dehumidifying. Allowing several minutes to stabilize, set the control to the most comfortable level of operation.

Representative values of dial setting verses input current to the thermoelectric modules are given below.

<u>Dial Setting</u>	<u>Input Current to Dehumidifier</u>
0	0.5 AMPS
15	3.5 AMPS
30	6.0 AMPS
40	8.0 AMPS

5. Before turning the unit on or off, the adjustable control should be set to zero (0).

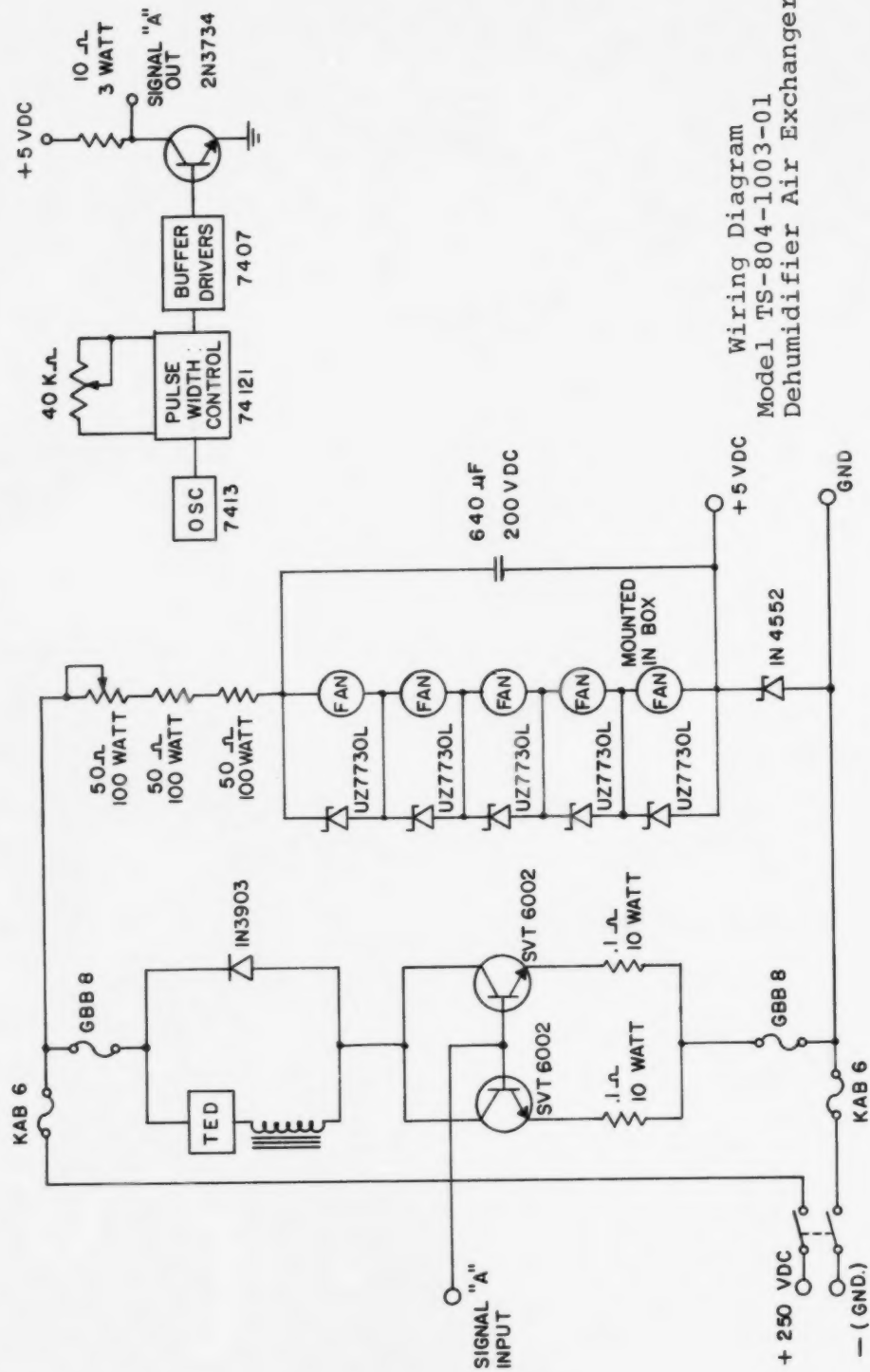
MAINTENANCE

The Cambion Model TS 804-1003 should provide reliable service with a minimum of maintenance. The only regular maintenance which should be required is the periodic cleaning of the heat sink on the cooling assembly. This can be easily accomplished by blowing accumulated dust and other foreign material out of the heat sink fins using compressed air.

TROUBLESHOOTING

Failure of the unit to operate can be traced to one of three areas: trouble in the power source, power supply, or cooling assembly. By following a systematic check-out of the three areas, the problem should be located with a minimum of difficulty. If the problem is found to be in either the power source or power supply, it may be possible for the customer to repair the system himself. See attached wiring diagram. If trouble is traced to the cooling assembly, the entire system should be returned to Cambion for repair.

A quick check of the thermoelectric modules can be made by connecting an OHM-meter across PINS A or B of the cooling assembly cable connector. A normal resistance reading is in the range of 10 to 100 OHMS. A reading outside of this range would indicate trouble in the thermoelectric modules.



APPENDIX D

INSTRUCTIONS FOR AUER OXYGEN SELF-RESCUER SSR 16 B TRANSLATED FROM MANUFACTURER'S BROCHURE FOR MSA RESEARCH CORPORATION

From the first page of the instructions

Advantages of the oxygen self-rescuer SSR 16 B over apparatuses using compressed air:

1. Lightweight: only weighs 1.3 kg.
2. A minimum of maintenance required. It is only necessary to occasionally, with the aid of the leak checking device, to make certain that the sealed carrying can remains tight.
3. Storing as directed provides for all practical purposes an unlimited storage life.

The Auer Oxygen Self-Rescuer SSR 16 B should not be stored at temperatures above 50°C.

In order to overhaul the apparatus after it has been used, special directions are applicable. (Replacing the used chemical canister and reconditioning or re-preparing for storage).

From the second page of the instructions

Every potential user of this apparatus should very carefully study the directions for using the Auer Oxygen Self-Rescuer SSR 16 B so that, in the case of an emergency, the necessary hand manipulations can be carried out fast and sure: the intent of the oxygen self-rescuer will only then be fulfilled when the self-rescuer can be put on fast when danger arises.

It is recommended that one practice putting on and wearing the oxygen self-rescuer with the continuously useable Auer practice apparatus, SSR 16 U (Order No. 115-701).

The correct way to put on the Auer Oxygen Self-Rescuer SSR 16 B is evident from the following directions:

1. Rip open the seal by giving a strong pull with the index finger on the red opener lever. Discard the lock band released thereby.
2. Pull off the lid from the apparatus and discard.

3. Pull the oxygen self-rescuer out of the lower part of the carrying can. (In the process, the Moosgum plate which protects the starting device falls down.) Discard lower portion of carrying can.
(There was no way to translate "Moosgum").
4. Hang the apparatus by the neck band around the neck so that the starting device with the red ring remains visible from the front. Using both hands, pull or spread the breathing bag apart.
5. Shorten the neck band by pulling the leather protected end on the right until the mouthpiece on the breathing tube is held to the mouth without necessitating any bowing of the head.
6. Breathe deep; then insert mouthpiece between lips and teeth so that the teeth bite on the biting surface and the lips tightly seal off the mouthpiece; then strongly exhale through the mouth into the apparatus.
7. Pull down the red rip ring (tear ring) of the starting device with a jerk in a perpendicular direction so that the pin holding the striker is completely pulled out.

8. Seal off the nose with the aid of the nose clamp.
Simultaneously using both hands, pull the rubber cushioning somewhat apart and shove it over the nose.
(The German translation said "nose wings". However, we can only guess at what is meant--perhaps it would be better stated by saying--place it over the nose so that it clamps the sides of the nose.)
9. Lock the locking device on the support strap behind the back. Breathe calmly.

APPENDIX E
SPECIFICATIONS
MINERS LIFE SUPPORT SYSTEM (MLSS)

The Miners Life Support System (MLSS) should be comprised of four basic components, the Mine Personnel Suit (MPS), the Mine Personnel Rebreather System (MPRS), the Mine Personnel Emergency Breathing System (MPEBS), and the Mine Personnel Communications System (MPCS). All components should be modular in construction for easy maintenance and a common system must be used throughout the mine.

Mine Personnel Suit (MPS)

The Mine Personnel Suit (MPS) should be a low pressure suit similar to those used by launch support (NASA) and emergency ordnance disposal personnel (USN). It must be constructed in such a manner as to provide freedom of movement as well as comfort in the sitting and lying positions.

Two styles of suit construction can meet air leakage criteria and each style should be evaluated to determine which one is best suited for the mining operation. The basic difference between them being the use of wrist and ankle seals versus the use of ventilated gloves and boots. All other specifications for the suits would remain the same.

The basic suit should have rigid seal rings at the wrists and ankles to provide effective seals for the use of special boots and gloves. Ventilating air would be blown into these gloves and boots. The hand protection should be by a two glove system consisting of a lightweight inner glove and a heavy exterior glove. Each glove would make an air tight seal at the wrist so as to prevent air from escaping should either glove be torn. The two glove system also provides for the removal of the outer heavy glove to perform delicate work using the lightweight inner glove. Should the lightweight glove be torn, the heavy glove can be put on to stop the air leakage.

The basic suit should have incorporated in it the ability to install snug wrist and ankle seals capable of meeting the leakage rate criteria to permit the testing of the suit while ordinary shoes and gloves are used by the miners. Ventilation must be provided to the seal area, while the hands and feet are exposed to mine atmosphere. This arrangement permits the use of bare hands in the performance of the work tasks.

The basic suit can meet a zero cubic foot per hour leakage rate when using special gloves and boots. The modified basic suit with wrist and ankle seals can meet the 1 cubic

foot per hour leakage rate, but may present the problem of excessive leakage due to the miners attempting to relieve possible discomfort at the wrist and ankle seals. The wrist and ankle seals eliminate the need for special gloves and boots and the hazard of tearing the gloves.

The Mine Personnel Suit (MPS) should consist of the assembly of the following components:

A knitted full length arm and leg undergarment as the first layer next to the skin.

The second layer should be a gas impervious suit of rubber coated fabric which is light in weight, meets the gas leakage specifications and has a distribution system to provide evaporative cooling (similar to the Navy's EOD suit, Industrial Environmental Protective Suit, Arrowhead Products SCAPE suit, etc.*).

The third or outer layer should be a wear resistant work garment designed to protect the gas impervious layer from excessive scuffing and tearing.

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The helmet would be attached by a clamping ring to the middle garment and be readily separable from the suit.

Special rubber gloves and boots complete the assembly for the basic style but would not be required for the alternate style using wrist and ankle seals.

SPECIFICATIONS

MINE PERSONNEL SUIT (MPS)

These recommended specifications cover the proposed requirements for a special clothing assembly or Mine Personnel Suit (MPS) which will meet the gas leakage requirements, keep the operator comfortable and be protected from excessive abrasions and tearing. A man should be able to don this clothing without assistance.

All garments are to be sized and graded to fit those in the 95 percentile. The design is to be such that a minimum number of sizes would be required.

The first or undergarment is to provide complete leg and arm coverage and is to be made of absorbent knitted cloth to provide maximum comfort for the wearer and to permit easy evaporation of perspiration to the circulating atmosphere in the suit. Standard Long Johns or thermal underwear may be suitable for this application.

The gas tight suit or second garment is to be constructed of a lightweight gas impervious flexible material treated with an anti-static compound to prevent the buildup of static

electricity. The suit is to be designed such that it can be put on and all gas tight closures--wrist, ankle, and head can be made by the miner without assistance.

Slide fasteners are to be used for the opening into the suit and are to be of such design as to maintain the leakage at less than 1 cubic foot per hour at 1/4 psig. All hand and foot enclosures or seals are to be designed to maintain the leakage requirements and to provide maximum comfort.

The gas tight suit is to terminate at the neck area with a suitable attachment device for mating with a separate helmet or head enclosure. This device is to provide for rapid removal of the helmet in case of emergency. The seal must be shielded in a way that sheds accumulations of dust and is readily wiped clean before resealing.

Ventilation ducts to distribute cool air throughout the garment and their connecting point on the suit are to be located so as not to interfere during sitting, lying, or standing, or in the manipulation of the arms in front of the body while operating mining equipment.

The total assembly, including the helmet, is to maintain a 1/4 psi differential over ambient pressure and must not leak

in excess of 1 cubic foot per hour at this differential. A maximum of 1 inch water pressure differential is the specified normal working pressure in the suit. Inflation of the garment is to be held to a minimum at this pressure so as not to restrict movement.

Lightweight rubber gloves with the appropriate gas tight seals are to be provided to permit a high degree of finger dexterity. A second pair of heavy duty rubber gloves with appropriate gas tight seals is to be provided for use over the lightweight gloves to provide a double gas seal in case the outer glove should be torn.

Heavy duty gas tight steel-toed boots with appropriate gas tight seals are to be provided.

The exterior work garment is to be made of cotton twill or similar fabric currently being used for work clothes. This garment is to protect the gas tight garment from abrasion and tearing. Scuff pads and special pockets may be required for tools, supplies, etc.

The head enclosure (helmet) is to be made from a polymeric material and is to be a dome-type of sufficient size to permit complete unrestricted head mobility and vision. It is

to be supported by the head and is to turn with head movements. Standard safety hat specifications are required. It is to be provided with a mounting bracket on top for a standard miner's lamp and is to be equipped to receive a single headset and lip microphone for communication purposes. Free flow of air is to be provided around the man's head for cooling and to prevent fogging of the visor. It is to be equipped with a voicemitter or tin ear over one ear for sensing in-mine noise. The visor is to be made of a scratch resistant material treated with lens anti-static compound.

SPECIFICATIONS

MINE PERSONNEL REBREATHING SYSTEM (MPRS)

The MPRS should be comprised of five components or subassemblies designed to be rapidly assembled into a self-contained rebreathing system. It should be compact, lightweight (less than 60 pounds) and provided with the necessary case and handles for ease in carrying. It should be designed for easy assembly and maintenance. All subassemblies should be modular in nature so that they may be easily interchanged and all connections must be readily accessible and require the minimum amount of special tools for changing.

The following subassemblies make up the proposed MPRS:

1. Oxygen source - compressed oxygen
2. Control panel and manifold
3. Air recirculating unit
4. Carbon dioxide canister
5. Air cooling unit

The first four of the subassemblies should be combined at least initially in a single unit, an oxygen module, while the fifth comprises the chiller module. The oxygen module

should be portable leaving and entering the mine with the miner while the chiller module remains on the assigned equipment. Quick disconnect fittings join the two modules. Ultimately the size and weight of the chiller module may be reduced so that the two may be combined in a single unit. The oxygen module must function to supply the miner with oxygen and CO₂ absorbing capacity at all times whether attached to the chiller module or being carried by the miner. Cooling of the miner obviously can only be accomplished when both oxygen and chiller modules are joined.

Subassembly 1 - Contains a cylinder of compressed oxygen at 2200 psig containing 2.4 pounds of oxygen. It includes the necessary high pressure reducing valve, quick disconnect couplings, hoses, and valves so that the subassembly can be quickly installed in the rebreather system.

Subassembly 2 - The control panel and manifold contains the demand pressure regulator, the pressure relief valve, oxygen sensor, switches, power supply and warning alarms required to make the completed assembly a safe and reliable rebreather system. It is to maintain an 0.1-0.5 water pressure at the suction of the rebreather blower at all times.

Subassembly 3 - The air circulator contains a 15 cubic foot per minute blower using a universal AC-DC motor, a rechargeable battery capable of providing for 2 hours operation of the blower, and appropriate disconnects, couplings, valves, hoses, switches, and flow control units as required to develop a complete and reliable air circulation system and maintain a maximum 1.0 inch water pressure within the suit.

Subassembly 4 - The CO₂ absorber consists of a canister containing Baralyme absorbant along with appropriate hoses and disconnects, switches, valves, etc., to facilitate rapid assembly into the completed unit. The canister must be capable of absorbing 3.3 pounds of CO₂ generated by the miner in a 12 hour period.

Subassembly 5 - The air cooling unit is comprised of the necessary mechanical refrigeration and reheating system with the associated hoses, valves, and disconnects so that the unit may be quickly assembled into the completed unit. It is to remove 2,000 BTU per hour (1.0 pound per hour of water) and when coupled into the completed MPRS to deliver 15 cfm air at 70°F and 40% relative humidity to the suit.

The completed assembly of the five components is to supply 15 cubic feet of air per minute at 70°F and 40% relative humidity to the suit while maintaining a 1.0 inch water pressure maximum in the suit when using a 20 foot dual tether hose 1.5 inches in diameter each.

SPECIFICATIONS

MINE PERSONNEL EMERGENCY BREATHING SYSTEM (MPEBS)

The Mine Personnel Emergency Breather System should be a self-contained rebreather system worn continuously by the miner. It must provide 30 minutes of oxygen and its size and weight is to be held to a minimum. It is to be located in such a manner so as not to interfere with the miner while operating his equipment and must require a minimum amount of effort to put it in service.

The MPEBS should consist of the following:

A mouthpiece with associated check valves and hose built into the helmet.

Quick disconnects on the helmets for the hose.

One superoxide canister with a 30 minute rating with a chlorate candle starter.

One collapsible breathing bag.

The necessary hose to complete the assembly.

All hose couplings should be of the quick disconnect positive seal type of the same manufacture used for the main rebreather system. All hose should be lightweight, flexible and crush resistant.

Mine Lamps

The mine lamp used with the MLSS should be the standard miners lamp in use today (the MSA Mine Spot for example). The MLSS helmet as proposed would contain a mounting bracket for this lamp. The battery may be the standard lead-acid battery with inner seals to prevent acid leakage regardless of the position of the battery. It is proposed that the present practice in handling, checking and charging the miner's lamp be used.

APPENDIX F

Mining Equipment Specifications

Phase II

ROOF DRILL

One (1) Galis Model 380 Roof Drill--Up or down drilling, Straight Rotary, Cable Reel less Cable for 440 volts A/C operation.

SPECIFICATIONS

Model 380 Dual Duty Drilling Machine

1. Permissibility: Permissible plate for electrical system will be supplied.
2. General Specifications:
 - a. Length 15'-0 Over Boom
 - b. Width 76" Over Rear Stabilizing Jack
 - c. Height 29" Minimum
 - d. Weight 9,950 pounds, approximately
 - e. Road Clearance 7" Minimum
 - f. Number of Wheels 4 (Four-Wheel Drive)
 - g. Tram Speed Variable to 188 FPM
 - h. Tires 7.50 - 10, 10 ply
 - i. Turning Radium Machine will rotate about its own center of gravity

- | | |
|---------------------|--|
| j. Brake | Hydraulic Disc type with
Parking Lock (optional at
no extra cost) |
| k. Drill | |
| 1. Number of Drills | One (1) |
| 2. Spindle Torque | 225' pounds (more on demand) |
| 3. Feed Length | 53" (with no part changes) |
| 4. Drill Speed | Variable to 475 RPM (Rotary)
Variable to 235 RPM (Rotary
Percussion) |
| 5. Feed Speed | Variable to 430 IPM |
| 6. Thrust | 8,000 pounds on demand |

- | | | |
|----|-------------------|---------------------|
| a. | Number of Motors | One (1) |
| b. | Speed | 1750 RPM |
| c. | HP rating | 30 HP AC |
| d. | Control Contactor | |
| | Type | Magnetic 100 ampere |
| e. | Cable Reel | Horizontal axis |
| f. | Voltage | 440 Volt AC |

4. Optional Features:

- a. Hydraulic disc brakes
- b. Dual tram and long low platform
- c. Hydraulic return fitter (Schroeder)
- d. Torquing Valve
- e. 500 ft. of #6/3 Type "G" Round Cable

SHUTTLE CAR

One (1) National Mine Service TorKar Type 48-S18-36A1
designed to operate on 250 Volt DC Power.

Standard Features:

Single motor--mine duty	43 HP, DC
Torque Converter	
Four-wheel drive	
Four-wheel steer	Orbitrol
Interchangeable wheel units	
Zoned and piped out lubrication	
Hydraulic brakes	
Automatic cable reel hydraulically operated	
Three-speed, forward and reverse transmissison	
Standard or opposite standard controls	
Conveyor speed, fast discharge with 15:1 Conveyor Drive	
providing discharge rate of 120 FPM or slower discharge of	
25:1 at 72 FPM.	
Conveyor chain 3.075" pitch, 90,000# Tensile Strength	
Flights--removable without separation of chain	
Sealed Beam headlights	

Permissible plate

Color--high visibility yellow

Auxiliary Lock-Up

Low Gear Starting

General Specifications:

Loaded height	36-1/16"
Height at loading end	17-5/16"
Overall length	25' 10-1/4"
Overall width	118"
Body width	114"
Conveyor width	61"
Capacity water level	175 cu. ft
with sideboards to 6"	226 cu. ft.
Clearance under frame	8-1/2"
Clearance under boom	
Lowered	13-3/4"
Raised	41"-1/8"
Boom extension	49"
Wheel base	7'10"
Turning radius	
Min. outside	21'4"
Min. inside	8'9"
Tire size	10.00 x 20

Weight - Approx.

25,500 pounds

Tram speed

Low

1.90 MPH

Second

3.00 MPH

High

4.00 MPH

Optional Features:

Fire Suppression System

500 ft. of 2/0 2 Conductor Type "G" Trailing Cable

CUTTING MACHINE

One (1) Joy Model 15RU3A Rubber Tired Cutting Machine, 440 Volts AC, Permissible, 34-1/2" in Height, 4" Ground Clearance, Less Cable, Hose Cut to Island Creek's length, 9' Bar and Cutter Chain, complete with all regular equipment and as shown of the following:

General Specifications:

	Low Model
Height:	35-1/2" w/ 4" g.c. AC 26-1/2" w/ 4" g.c. DC
Length (less bar)	24'11" AC 24'3" DC
Width--over duals	104"
over running boards	96-3/4"
over single wheels	not recommended
Weight (approx.)	36,000 pounds
Ground Clearance	4" Std.
Options	6"
Cutting Range w/ Std. Ground Clearance	
Below Bottom	6-5/8" AC 4-5/8" DC
Top Cut (Std.)	8'10" AC 8" DC

Wheel base	95"
Tire Size - Dual Drive	8.25 x 15
Steer	8.25 x 15
Single Drive	not recommended
Tram Speed (Max.)	200'/min.
Optional Maximum	250'/min.
Hydraulic Pump	50-15 GPM
Hyd. Tank Capacity	115 gallons
Motor Rating (1 Hour 90°C Rise)	
Pump DC	45 HP
Cutting DC	140 HP
Pump AC	65 HP
Cutting AC	185 HP

Regular Equipment Furnished

9 foot Cutter Bar

Single Drive Tires

One Front Headlight and Rear Reflector

Hydraulic Cylinder Actuated Brakes on Driving Transmissions

Vertical Axis Cable Reel

Bumper Mounted Auxiliary Oil Tank

Optional Features

Extra Cutter Bar Length

Water Type Cutter Bar

Wheel Base 95"

Amp & Hour Meter - Cutting Motor AC only

Bugduster - Dual Drive Unit

Four Wheel Drive

Roof and Floor Jack - rear corner only

500 ft. of 2/0 3 Conductor Flat Type "G" Cable

Schroeder Filter

LOADING MACHINE

One (1) Joy Model 14BU10-31BH Crawler Mounted Loading Machine, 33" in Height, with 38" Wide Conveyor, Less Cable, Return Line Oil Filter, with Hydraulic Hose Cut to Island Creek's length, complete with all regular equipment.

SPECIFICATIONS

General

For Dimensions, See Sales Dwg. BU695

Seam height 38" or higher

Capacity 15-30 tons per minute

Conveyor 38" wide - 3" pitch chain

Conveyor Pan Height - 25"

Crawler Chain 12" wide x 4" pitch

Gearing - simple spur or bevel type - no worm gearing

Weight (less cable) 36,000 pounds

Electrics

Two head motors at 50 HP each

Two traction motors at 25/12.5 HP (two speed windings)

One pump motor at 10 HP

Special Trimming - Hi	130 FPM, 60 Cycle	108 FPM, 50 Cycle
Lo	65 RPM, 60 Cycle	54 FPM, 50 Cycle
Gath. Arm Speed	58 RPM, 60 Cycle	48 RPM, 50 Cycle
Conv. Chain Speed	450 FPM, 60 Cycle	375 FPM, 50 Cycle

Swing Out Control Panels

Liquid Filled Traction Motors (60 Cycle Only)

Circuit Breaker in Master Switch

Hydraulics

Hyd. Oil Tank Capacity - 7 gal.

Total Hyd. Oil Capacity - 9.5 gal.

Automatic oilers on traction drive chain

Automatic flushing of labyrinth only (on gath. head gear pots)

Cross line relief valve in conv. swing circuit

Relief valve in conv. lift circuit

Standard Features

1. Gearing. 18 of the 26 gears used are interchangeable with all 14BU10 Models. Only 3 different part numbers from those used in 14BU10-11 models.

2. Patented collapsible footshaft
3. Pressure lubricated heavy duty head clutches
4. Direct drive to gathering arms
5. Replaceable wear shoe in crawler frames
6. Ball brg. type tail roller
7. Permissible Plate
8. Three repair parts catalogs
9. Three maintenance manuals
10. Special tools
11. Hydraulic hoses - double wire braid with reuseable
J. I. C. Fittings (female swivel fittings).

Optional Features

1. 500' Trailing Cable Size #1
2. Operator's Seat
3. Hard surfacing-head deck and gath. arms
4. Reversing Conveyor

FACE DRILL

One (1) Galis Model 460 Face Drill, orbital feed, 11' feed, rotate head with Carmet Adapter and Jacket for water drilling, hydraulic disc brakes, cable reel less cable, for 440 volt AC operation.

SPECIFICATIONS

Galis Model 460 Face Drill

General Specifications

1. Length	22'-0"
2. Width	6'-6" over tires, 7'-6" over operator's deck
3. Height	24"
4. Weight	8,800 pounds, approximately
5. Road Clearance	5"
6. Tram Speed	190 FPM
7. Rear Tires	6.50 x 10, 10 ply
8. Front tires	15-1/2 x 6 x 10 solid tire
9. Parking Brake	Disc Type
10. Drill	
a. number of drills	One (1)

b. spindle speed	Variable to 2200 RPM
c. feed length	11'-0"
d. drill thrust	1,000 pounds, nominal

Electrical Specifications

1. Number of Motors	One (1)
2. Speed	1750 RPM
3. HP Rating	30 HP AC
4. Voltage	440 AC
5. Control Contactor Type	Magnetic, 100 ampere
6. Cable Reel	Horizontal

Optional Features

- Schroeder Filter
- 500 ft. #4/3 Conductor Type "G" Flat Cable

Combination AC & DC Transformer

Rectifier Unit 500 KVA AC

150 Kw. DC

ELECTRICAL SPECIFICATIONS

500 KVA, ventilated, skid mounted, transformer to have the following features:

- (1) 500 KVA, three phase, three winding, class H insulated 150°C rise transformer core and coils. Primary 1460V with two 2-1/2% full capacity taps above and below normal. Low voltage 480Y/277. Other low voltage winding to feed 150 Kw. 275 volts DC silicon rectifier.
- (2) Three oil fused cutouts, 5200 volt, 200 amp, G.E. Model 9F32FCA207. Each equipped with 150 amp fuse links G.E. Model 9F57CAA150.
- (3) One rack and gang operating mechanism for above cutouts G.E. Model 9F31RBR301.
- (4) One PMG375, and one SFG375, 7500 volt, 300 amp gear mounted plug and socket used in feed through configuration with provision for Kirklocks both positions.

- (5) Three lightning arrestors for 4160 volt side. Type RM Style No. 1616454.
- (6) Neutral grounding resistor 11.2 ohms, 25 amp, continuous duty.
- (7) Two MAA 800 molded case circuit breakers with 800A thermal trip and 480 volt shunt trip less cut-off switch. Magnetic trip range to be 1500 to 300 amp. Ship set on "Lo" position.
- (8) Window type current transformers driving induction disc type relays for time delay ground trip on each breaker. Ground check circuits to be employed on each low voltage circuit.
- (9) Each secondary circuit is to terminate in two Ensign 400 amp, six pole No. RG40DFC49 receptacle with dust cover and mating plug for 4/0 PCG 600 volt cable.
- (10) 275 volt DC to terminate in Ensign gear mounted receptacle No. RG40DFC84 with control contacts interlocked with rectifier circuit breaker.

- (11) 150 Kw. convection cooled silicon rectifier with protective circuit breaker in AC input leads. Furnish breaker with 120 volt AC under voltage trip for interlocking.

SAFETY CIRCUIT CENTER AC

AC Safety Circuit Center, Upright, Skid Mounted, 480 volt, 3 phase, 60 cycle. Equip with 1-600 amp, 2-400 amp, and 2-100 amp breakers with overcurrent and ground trip, incoming gear mounted plug with mating line socket for #4/0 3 Cond. PCG cable with ground check circuit, 5-load outlets with blank caps and five matching line plugs. Load outlets are: 400 amp "Cutter", 400 amp "Loader", 400 amp "Pick Breaker", 100 amp "Coal Drill", 100 amp "Roof Bolter".

All plugs and sockets are to be Ensign Electric and Manufacturing Company.

LOAD OUTLETS

<u>Machine</u>	<u>Cable Size</u>	<u>Magnetic Trip Range</u>
Cutter	#2/0, 3 Cond. Flat G	1250-2500 Amps.
Loader	#1, 3 Cond. Flat G	1000-2000 Amps.
Pick Breaker	#1/0, 3 Cond. Round G	1000-2000 Amps.
Coal Drill	#6, 3 Cond. Flat G	160-560 Amps
Roof Drill	#6, 3 Cond. Round G	160-560 Amps.

SAFETY CIRCUIT CENTER DC

DC Safety Circuit Center, Upright, Skid Mounted, 285 volts, two wire equip with incoming cable gland for No. 4/0 2-cond. Type G 600 volt rubber insulated cable, four contactor type circuit breakers with adjustable instantaneous overload relays, one for Joy 14-9 loader and three for Joy Type 18SC-10 Shuttle Cars. Furnish each outlet circuit with Miller single conductor plugs and receptacles. Polarize by using male and female gear mounted units. Furnish chain and cable clamps for strain relief of each cable circuit. Cable sizes will be furnished with order.

5 Kv. Mine Power Cable

1000 Ft. Lengths No. 1/0 copper, 3 - conductor 5 Kv. Mine Power Cable, semi-conduction tape .090" cross-linked polyethylene insulation, semi conducting tape, fillers, 2 ground wires, 1 - minimum #8 A.W.G. insulated ground check wire tape and neoprene jacket.

High Voltage Cable Couplers

Pai High Voltage Cable Couplers each consisting of one PLM Cat. No. PM375A and one PLM Cat. No. SF375A connector. Drill power contacts 1/2", drill socket for Kirk Lock and furnish cable gland for 1.52" O.D. cable.

High Voltage Gang Operated

Load Break Switch

1 - S & C Electric Company Cat. No. 37011R3 Alduti type outdoor gang operated switch, 3 pole, 7.5 Kv., 600 Amp., clockwise opening, furnish with Cat. No. ED - 90 operating mechanism for 30 ft. mounting.

6 - S & C Electric Co. Cat. No. N4741 - RC connectors #2 to 500 MCM copper or aluminum connector. For use with above switch.

APPENDIX G

SPECIFICATIONS FOR COMMUNICATIONS SYSTEM

REMOTE CONTROL BASE STATION RADIO

Manufacturer: Motorola Communications and Electronics,
Inc.

Model Number: C73MHB-110-R with carrier squelch

Frequency: 136-174 MHZ

RF Output: 110 watts minimum

Plate Output: 200 watts maximum

Input Voltage: 117 vac at 50/60 Hz

Dimensions: 22" wide x 30 1/4" high x 8" deep

Weight: 108 lbs.

PERSONNEL FM RADIO

Manufacturer: Motorola Communications and Electronics,
Inc.

Unit: HT 220 Series "Handie-Talkie" FM Radio

Model Number: H23FFN-1104 N

Universal unit with voice-operated relay
and squelch

Frequency: 150.8 - 174 MHZ
FCC Designation: CC3526 (1.9 watt)
Power Supply: Rechargeable Nickel-Cadmium Battery
with 12 hour life
Weight: 30.5 ounces (with nickel-cadmium battery)
Dimensions: 6.95" x 3.19" x 1.69"

ANTENNA CABLE

Conductors: Two No. 10 AWG, Solid Bare Soft Copper

Dielectric: Shaped polyethylene extrusion approximately rectangular, with rounded corners having an air hole in the center

Outer Covering: .035" nominal wall of gray, flame retardant polyethylene

Overall Dimensions: 1.5" x .800" with nominal rounded corners

Weight: .35 pounds per foot, nominal

Installation: Cable shall be properly installed on hangers at least 8" from all metal objects which shall be spaced no less than 8' nor more than 10'

Electrical Characteristics:

Characteristic Impedance - 300 Ohms nominal

Capacitance - 4.1 pf. per foot nominal

Velocity of Propagation - 82%

Attenuation - .7 db/100 feet maximum at 160 MHZ (Factory Test)

.9 db/100 feet maximum at 160 MHZ

Dielectric Strength

- This cable is designed to withstand a 5,000 volt RMS potential applied from conductors to a water bath surrounding the cable. Since the cable is extremely buoyant, this test is conducted on short sample pieces forcibly held submerged below water.

Flame Retardancy: Exceeds U/L-83 Vertical Flame Test

Reel Lengths: For substantial production quantities, lengths up to one mile can be produced with reasonable allowance for some lengths as short as 1,000 feet

Manufacturer: The Plastic Wire and Cable Corporation
Jewitt City, Connecticut

HEARING AID

Manufacturer: Radioear Corporation

General: Model 980 is a high gain, high power output, low distortion, wide range, body type hearing aid. All adjustments may be made from the outside of the instrument without removing the case. The Model 980 has completely unitized construction, making servicing simple without the need for special tools.

Size: 1.7" wide x 2.6" high x .67 thick

Weight: 2.7 ounces, including type 401 battery

Battery: 1 Type 401 Cell, 1.3 volts

Battery Drain: Related to control settings and ambient noise level.

One-Cell Operation

No Saturation Cut	5.5 MA to 10.0 MA
5 dB Saturation Cut	4.5 MA to 6.5 MA
10 dB Saturation Cut	3.5 MA to 4.5 MA

Battery Life: Related to control settings and ambient noise level.

One-Cell Operation

No Saturation Cut	80 to 145 hours
5 dB Saturation Cut	123 to 178 hours
10 dB Saturation Cut	178 to 228 hours

Microphone: Wide range, smooth frequency response, barium titanate ceramic type. Resiliently mounted in shockproof neoprene gasket. Essentially unaffected over a wide range of temperature and humidity conditions.

Amplifier: Compact 6-transistor temperature stabilized circuit. Class AB push-pull output stage. All components mounted on individual gold plated terminals. High strength glass epoxy chassis.

Air Receivers: Magnetic type with high sound level handling capability. M-98 is standard 120 ohms impedance. An alternate receiver for "Y" cord fittings is the M-99 receiver--240 ohms impedance. Receivers are center tapped to permit direct connection to push-pull output stage without the necessity of using an output transformer.

Bone Conduction Receiver: B-98 Type - 100 ohms nominal impedance, center tapped. High sensitivity and output, stable design.

Case: The case is stainless steel, highly polished to a surface smoothness typically less than 1.0 microinch. The battery

support is made of Tenite II and is separated from the instrument by the metal case. The battery cover and knobs are also molded of tough, lustrous Tenite II.

Selector Switch: Rugged detent action type with pure coin silver contact elements. Four positions are available--"OFF", "MICROPHONE", "MICROPHONE-TELEPHONE" and "TELEPHONE".

APPENDIX H
OFFICE AND TEST BUILDING
DRAWING LIST
(AS DESIGNED)

<u>Dwg. No.</u>	<u>Title</u>
6135-2A1	Project Site - General Arrangement
6135-2A2	Office and Equipment Test Building - General Arrangement - Plan and Elevation
6135-2A3	Office and Equipment Test Building - General Arrangement - Elevation and End View
6135-2A4	Office and Equipment Test Building - General Arrangement - Floor Plan
6135-2A5	Project Site - General Arrangement
6135-3A1	Office and Equipment Test Building - General Arrangement - Foundation Plan and Sections
6135-5A1	Office and Equipment Test Building - General Arrangement - Piping Water Supply
6135-5A2	Office and Equipment Test Building - Vent and Drain Piping
6135-5A3	Office and Equipment Test Building - Vent and Drain Piping Details
6135-5A4	Office and Equipment Test Building - Sewage treatment Plant - Plan and Section

OFFICE AND TEST BUILDING

DRAWING LIST

(AS DESIGNED)

<u>Dwg. No.</u>	<u>Title</u>
6135-5A5	Office and Equipment Test Building - Piping Water Supply - Sections
6135-6A1	Office and Equipment Test Building - Electri- cal Single Line Panel - Diagrams and Lighting Details
6135-6A2	Office and Equipment Test Building - Electri- cal Lighting Plan and Sections
6135-6A3	Office and Equipment Test Building - Electri- cal Heating and Ventilation - Arrangement and Details

APPENDIX I
OFFICE AND TEST BUILDING
DRAWING LIST
(AS BUILT)

<u>Dwg. No.</u>	<u>Title</u>
6135-2A1	Project Site - General Arrangement
6135-2B2	Office and Equipment Test Building - General Arrangement - Plan and Elevation
6135-2B3	Office and Equipment Test Building - General Arrangement - Elevation and End View
6135-2B4	Office and Equipment Test Building - General Arrangement - Floor Plan
6135-2B5	Project Site - General Arrangement
6135-3B1	Office and Equipment Test Building - General Arrangement - Foundation Plan and Sections
6135-5B1	Office and Equipment Test Building - General Arrangement - Piping Water Supply
6135-5B2	Office and Equipment Test Building - Vent and Drain Piping
6135-5B3	Office and Equipment Test Building - Vent and Drain Piping Details
6135-5B4	Office and Equipment Test Building - Sewage Treatment Plant - Plan and Section

OFFICE AND TEST BUILDING

DRAWING LIST

(AS BUILT)

(Cont'd.)

<u>Dwg. No.</u>	<u>Title</u>
6135-5B5	Office and Equipment Test Building - Piping Water Supply - Sections
6135-6B1	Office and Equipment Test Building - Electri- cal Single Line Panel - Diagrams and Lighting Details
6135-6B2	Office and Equipment Test Building - Electri- cal Lighting Plan and Sections
6135-6B3	Office and Equipment Test Building - Electri- cal Heating and Ventilation - Arrangement and Details

APPENDIX J
DEMONSTRATION MINE
DRAWING LIST

<u>Dwg. No.</u>	<u>Title</u>
6135-2A10	Project Site - General Arrangement - Demonstration Mine
6135-2A11	Refuge Station - General Arrangement - Demonstration Mine
6135-2A12	Refuge Station Ventilation System - General Arrangement - Demonstration Mine
6135-2A13	Personnel Lock - General Arrangement Demonstration Mine
6134-2A14	Equipment and Personnel Lock - General Arrangement - Demonstration Mine
6135-2A15	Equipment Building - General Arrangement - Demonstration Mine
6135-2A16	Equipment Building - Sections - Demonstration Mine
6135-2A17	Office Building Demonstration Mine - General Arrangement - Plan and Elevation
6135-2A18	Office Building Demonstration Mine - General Arrangement - Elevation and End View

DEMONSTRATION MINE

DRAWING LIST

(Cont'd.)

<u>Dwg. No.</u>	<u>Title</u>
6135-2A19	Office Building Demonstration Mine - General Arrangement - Floor Plan
6135-2A20	Equipment Building - Sections Demonstration Mine
6135-2A21	Demonstration Mine - General Arrangement - Mine Seal @ ROM Conveyor
6135-3A10	Office Building Demonstration Mine - General Arrangement - Foundation Plan and Sections
6135-5A10	Demonstration Mine - Water System - Flow Diagram
6135-5A11	Demonstration Mine - Inert Gas system - Flow Diagram
6135-5A12	Demonstration Mine - Monitor and Interlock Instrument Diagram
6135-5A13	Cooling Tower, Hot Well and Cold Well - General Arrangement - Demonstration Mine
6135-5A14	Man Cooling Manifold Blower - Arrangement and Detail - Demonstration Mine

DEMONSTRATION MINE

DRAWING LIST

(Cont'd.)

<u>Dwg. No.</u>	<u>Title</u>
6135-5A15	Office Building Demonstration Mine - General Arrangement - Piping Water Supply
6135-5A16	Office Building Demonstration Mine - Vent and Drain Piping
6135-5A17	Office Building Demonstration Mine - Vent and Drain Piping Details
6135-5A18	Office Building Demonstration Mine - Sewage Treatment Plant - Plan and Section
6135-5A19	Office Building Demonstration Mine - Piping Water Supply - Details
6135-5A20	Cooling Tower, Hot Well and Cold Well - Sections - Demonstration Mine
6135-5A21	Water and Sewer Lines - General Arrangement - Demonstration Mine
6135-5A22	Inert Gas and Air Lines - General Arrangement - Demonstration Mine
6135-6A10	Electrical Plot Plan - Demonstration Mine

DEMONSTRATION MINE

DRAWING LIST

(Cont'd.)

<u>Dwg. No.</u>	<u>Title</u>
6135-6A11	Office Building Demonstration Mine - Panel Diagrams, Single Line - and Lighting Detail
6135-6A12	Office Building Demonstration Mine - Electrical Lighting Plan and Sections
6135-6A13	Office Building Demonstration Mine - Electrical Heating and Ventilation - Arrangement and Details
6135-6A14	Demonstration Mine - Control Panel CP-1 - Arrangement
6135-6A15	Power Distribution - Single Line Diagram for Demonstration Mine
6135-6A16	Power, Control and Instrumentation Diagram - Sheet #1, Demonstration Mine
6135-6A17	Power, Control and Instrumentation Diagram - Sheet #2, Demonstration Mine

APPENDIX K

Mining Equipment Specifications

Demonstration Mine

FEEDER BREAKER

One (1) Stamler BF-17-8 Feeder Breakers (or equal) with specifications as follows:

A. Electrical

- | | |
|-------------------|--|
| 1. Conveyor Motor | 75 HP 1800 RPM, 480 VAC
3 ph., 60 cycle, TEFC enclosure, NEMA Design B |
| 2. Breaker Motor | Same as above |
| 3. Starter | Dual 75 HP, 440 VAC, 3 phase
60 cycle, magnetic full voltage across the line starter in NEMA 12 enclosure |
| 4. Belt Switch | Ensign with 50' of cord |
| 5. Training Cable | 500' of 1/0-3 conductor type "G" round |

B. Gear Reducers

- | | |
|-------------|----------------------------|
| 1. Conveyor | Cone Drive Size 7800-54 HP |
| 2. Breaker | Cone Drive Size 7800-99 HP |

3. Tram

Double orbit motor driven
pinion gear to bull gear on
drive sprocket

C. Coupling

1. Breaker & conveyor

Dodge paraflex PX100

D. Conveyor

1. Width

44"

2. Chain

3.075 Pitch, 147,000 Ultimate
per strand (294,000 total)

3. Flights

1 3/4" x 4" solid steel

4. Head shaft

3 1/2" dia. w/ 3-1/2" bearing

5. Tail shaft

3 1/2" dia. w/ 3-1/2" bearings
removable as a unit

6. Take up

By grease cylinder

7. Relief

Shear pin hub

8. Ratioing

By adjustable plates and
chains

9. Speed

75 FPM

e. Breaker

- | | |
|-----------------------------|--------------------------------|
| 1. Direction of rotation | With the flow of material |
| 2. Height setting | Adjustable |
| 3. Relief | Shear pin hum in breaker drive |
| 4. Reducer to breaker shaft | |
| drive | Chain D160 ASA |
| 5. Bit | Pic Type - replaceable |
| 6. Breaker Shaft | 7" dia. |
| 7. Bearing | 4-7/16" spherical roller |

F. Crawlers

- | | |
|------------|--------------------|
| 1. Speed | 40 FPM |
| 2. Drive | Hydraulic |
| 3. Take up | By grease cylinder |

G. Structure

- | | |
|-----------------|---|
| 1. Side members | 9" ship channel @ 25.4 ft. |
| 2. Bed plate | 1 1/2" AR steel on intake end
2 7/8" AR steel under the
breaker |
| 3. Articulation | Pivoted on front axle by
hydraulic jack on back axle |
| 4. Side boards | 8" hinged |

H. Dimensions

- | | |
|---------------------|---|
| 1. Length | 29'-6" |
| 2. Width | 9'-6" |
| 3. Tram height | 34" (without side boards)
42" (with side boards) |
| 4. Ground Clearance | 4" |

I. Hopper

- | | |
|-------------|--------|
| 1. Capacity | 8 tons |
|-------------|--------|

J. Trailing Cable

500' lengths (2,000' Total) #1/0-3 type "G" Trailing Cable for use with Feeder Breakers.

UNDERGROUND BELT CONVEYOR

1. General Specifications

- | | |
|---|---------------------|
| a. Quantity | One (1) |
| b. Belt width | 36" |
| c. Length | 740 ft. |
| d. Maximum distance material
is raised or lowered
(fpm) | Undetermined
500 |

HEAD END

Head Section

1. Type of Drive

Internal single power unit, dual driving pulleys, geared

2. Pulleys (for maximum belt width)

<u>Type</u>	<u>Number</u>	<u>Diameter</u>	Thickness and Type of Lagging
			<u>(if any)</u>
Driving	2	21"	1/2" vulcanized Neoprene (grooved)
Idler snub	-	-	-
Idler Head	1	21"	1/2" vulcanized Neoprene

3. Dimensions of Head Section

- a. Overall height 34"
- b. Minimum moving height 34"
- c. Height under discharge
pulleys 5-1/2 - 70"
- d. Length of boom
overhang 5'-5"
- e. Overall length 16"
- f. Overall width 6'-8"

4. Special Features

Chute type belt wiper, adjustable boom height

Power Unit

5. Location of Power Unit

Internal - behind drive pulleys

6. Electric Motors

a. Manufacturer	G.E., Reliance, Allis Chalmers
b. Horsepower (con- tinuous)	100
c. RPM	1750
d. Volts	440
e. Phase	3
f. Cycle	60
g. Enclosure	TEFC
H. NEMA Design	Wound Rotor

7. Speed Reducer

a. Manufacturer	Falk
b. Thermal Horsepower	128
c. Mechanical horsepower	128

d. Class of Service	1.25
e. Type and Size	75C202
f. Ratio (to 1)	9.49

8. Controller

a. Manufacturer	Ensign
b. Volts	440
c. Phase	3
d. Cycles	60
e. Type and Size	Bulletin 26100, magnetic, red voltage, single speed single Mtr.
f. Mounting	Skid
g. Enclosure	NEMA 12
h. Reversing	Manual
i. Reversing	No
j. Other features	Per wiring diagram 4WD-1892 50 ft. cable - controller to motor

9. Other Components of Power Unit

- a. Oil tight chain gaurd between reducer and drive pulley.

- b. Dust tight centrifugal roller switch for belt slip protection.
- c. Dust tight centrifugal roller switch for sequence starting
- d. 740 ft. No. 14/3 Type SO Control Cable

Head End Belt Take-up

10. Type of Head End Belt Take-up

Automatic internal hydraulic

11. Pulleys

- | | |
|-------------|---------------|
| a. Fixed: | Number: 1 |
| | Diameter: 16" |
| b. Movable: | Number: 1 |
| | Diameter: 16" |

12. Length of Travel for Movable Pulley

- | | |
|----------------------|--------|
| a. Without resetting | |
| tensioning unit | 10 ft. |
| b. By resetting | |
| tensioning unit | 20 ft. |

13. Overall Length of Take-up Unit

Approximately 28 feet

14. Special Features

- a. Open type, 440/3/60 AC Power Unit; tensioning side interlocked with conveyor drive to prevent starting before slack side tension is attained.

TAIL END

1. Dimensions of Tail Section

- a. Overall length 14'
- b. Overall width 6'-0"
- c. Loading height 16"

2. Tail Pulley

- a. Type Fluted self-cleaning
- b. Diameter 16"

3. Plows for Cleaning Return Belt

- | | |
|--------------------|-----------|
| a. Number provided | One |
| b. Type | Plow type |

4. Tail End Take-up

- | | |
|---|------------------|
| a. Description | Tensioning jacks |
| b. Number of tensioning
jacks provided | 2 |

5. Tail End Loading Hopper

- | | |
|-------------------------------|---------|
| a. Integral | Yes |
| b. Separate | No |
| c. For conveyor loading | Yes |
| d. For shuttle car
loading | Yes |
| 3. Height loading | |
| e. Height loading
overside | 25 1/2" |
| f. Height loading
over end | 23" |
| g. Overall length | 14'-0" |
| h. Overall width | 6'-0" |

INTERMEDIATE SECTION

1. Rigid framed

No

2. Wire Rope Framed

a. Carrying idler

centers 5 ft.

b. Return idler centers 10 ft.

c. Overall support height:

maximum: 20 1/2"

minimum: 13 1/2"

fixed: variable

d. Rope height:

maximum: 20 1/2"

minimum: 13 1/2"

fixed: variable

e. Wire rope diameter

and type:

5/8" Dia., 6 x 19 regular lay, steel core, bright

f. Anchors:

Centers 250

Type and description Floor type complete with hardware for four (4) tie-off points.

3. Idlers

<u>Item</u>	<u>Carrying</u>	<u>Return</u>
Type 25° cradle	Offset	Plain
Roll diameter	4"	4"
Material	9 Ga. Steel	9 Ga. Steel
Bearing	Timken	Timken
	Roller	Roller
Shaft bearing	3/4"	3/4"

Additional description: See Tail Section for idlers
included with it.

BELTING

1. Belt Specifications

a. Length	ft. rools PVC Belting
b. Width	36"
c. Fire resistant	Yes
d. Other types of belting	3,000 lb. Minimum Tensile Strength per inch of width

2. Splices

a. Type	Factory applied Hayden-Nilos
---------	------------------------------

112 1/2 KVA BELT TRANSFORMER

ELECTRICAL SPECIFICATIONS

112 1/2 KVA, ventilated, skid-mounted transformer to have the following features:

- (1) Three 37 1/2 KVA single phase, class H insulated, 150° C rise transformer core and coils. Primary 4160 volt with 2-2 1/2% taps above and below normal. Low voltage 480Y/277, for self-ventilated application. Standard impedance.
- (2) Three oil fused cutout, 4200 volt, 100 amp. GE Model 9F32FCA104 with operating mechanism and 30 amp GE Model 9F57CAA030 fuse links for above.
- (3) Three lightning arrestors, type RM Style No. 1616454.
- (4) One PMG375 and one SFT375, 7500 volt, 300 amp gear mounted plug and socked used in feed through configuration with provision for Kirklocks both positions.
- (5) 25 amp Continuous-duty neutral resistor.
- (6) Two low voltage molded case circuit breakers. One JA 3225 with 480 volt shunt trip less cut-off switch,

1125 to 2250 amp trip range set on "Lo" position and one F3100 with 480 volt shunt trip less cut-off switch.

- (7) Window current transformers and ground trip relaying equipment on each secondary circuit.
- (8) The secondary circuit from the JA frame breaker to terminate in Ensign No. RG17DFM06 receptacle with mating plug and dust cover for #1/0-3C-G Cable. The secondary circuit from the F frame breaker is also to terminate in Ensign No. RC17DFM06 receptacle with mating plug and dust cover, for #2-3C-G-R Cable.
- (9) Pulling hook on all four corners.

OPERATING PERSONNEL CARRIER

1. Kersey Model PC-12, type 27 (or equal) 3 wheel type
2. Axle 2,000 lb., Power-Lok
3. Battery 12 cell, 5.4 KWH capacity
4. Warning Bell - 6" trip gong
5. Brake - Mechanical foot and parking brake
6. Controller - Contractor foot control
7. Dimensions - 22" h. x 57" w. x 8'-6" l.
8. Lights - 12 Volt sealed beam front and rear
9. Motor - 2 HP Series wound
10. Speed - 2 Forward 2 & 5 MPS
1 Reverse 2 MPS
11. Tires - Front 5.00 x 8 - 8 Ply, Rear 6.00 x 9 - 10 Ply
12. Battery Charger
 - a. Kersey Model AlX (or equal) automatic silicon diode complete with automatic rate reduction and electric timers, upright, skid mounted, open type connectors, 110V., 1Ph., 60 Cy., AC supply.

SUPPLY UNITS

1. Kersey Model 1144-D tractor (or equal) open type.
 - a. Axle Assemblies - rated 10,000 lb. each.
 - b. Motor - Two 20 HP, series wound, special design for battery traction service.
 - c. Control - 3 speeds each direction to 10 PMH
 - d. Lights - 48 volt, 75 wat sealed beam, one each end
 - e. Speed Reducer - two, 20 HP ball or roller gearings throughout
 - f. Brakes - two hydraulic disc type, with latch for parking.
 - g. Steering- Four wheel steer
 - h. Battery - not included, to be leased
 - i. Weight - less battery, 10,200 lbs.
 - j. Seat - spring mounted operator's seat
 - k. Warning Bell - 8 inch, foot operated
 - l. Tires - 7.00 x 15
 - m. 90 Volt Power Take Off
 - n. Detachable 30" front cargo deck
 - o. Recharge reminder

2. Battery Chargers - (one for each tractor)
 - a. Kersey Model 3A8Z (or equal) Automatic Silicon diode complete with automatic rate reduction and electric timers, upright, skid mounted, open type connectors. 440V., 3 Ph., 60 Cy., AC Supply.
3. Supply Cars - Kersey (or equal) Model 68-12
 - a. Bed size - 6' wide x 8' long x 6" ground clearance, 12" sides above bed, 4" sills
 - b. Capacity - 5 tons
 - c. Tires - 6.50 x 10 pneumatic - 10 Ply with K-158 hubs.

COAL REMOVAL

DRAG TANK

General

Type	Double Sliding Chain
Incline	30°
Incline Centers	31.9 ft.
Capacity	360 TPH @ 100 FPM
Flights	
1. Length	36 in.
2. Depth	12-5/8 in.
3. Spacing	24 in.
Shaft Diameters	
1. Head	4-7/16 in.
2. Foot	3-15/16 in.
Terminal Weight, Avg.	2456 lbs.
Chain and Flight, wt/ft	31.8 lbs.

Conveyor Chain

Type	Rivetless
Pitch	6-1/32 in.
Avg. Ultimate Strength	100,000 lbs.
Weight/ft.	11.4 lbs.
Links/10 ft.	20

Sprockets

Type	Flint-Rim, 10,000 lb. chain pull
------	-------------------------------------

Head Sprocket

1. Teeth	7
2. Bore	4-7/16 in.
3. Bore Length	6 in.
4. Weight	221 lbs.
5. Pitch Diameter	26.96 in.

Foot

1. Teeth	6
2. Bore	3-15/16 in.
3. Bore Length	5-1/2 in.
4. Weight	159 lbs.
5. Pitch Diameter	23.18 in.

Conveyor Drive

Motor

Type	Wound Rotor, 60 cycle, 3 phase
Voltage	440V AC
Speed	1800 RPM Synchronous
Horsepower	30 HP

Starter

Specified by motor manufacturer
with particular motor delivered.

Speed Reducer

Type

Horizontal Concentric,
Wormgear Reduction

Input (High Speed)

1750 RPM

Output (Low Speed)

37 RPM

COAL HANDLING STACKER CONVEYOR

One (1) Stone Model RSM non-elevating radial stacking conveyor approximately 100' long O.A. x 36" belt width with the following features:

- a. Heavy duty self-cleaning 48" deep jig welded pipe truss with 2 7/8" O.D. structural chord members
- b. 3-Roll x 35° x 5" dia. sealed ball bearing troughing idlers at 4' intervals
- c. 5" dia. sealed ball bearing returns at 10' intervals.
- d. Heavy duty rubber skirted load hipper with (2) additional load point idlers
- e. "Link Belt" or equal, 307 D 20 shaft mounted reducer with built-in hold back brake
- f. Guarded V-belts and sheaves for 400 FPM belt speed
- g. Wrap drive arrangement with belt take-up
- h. 24" dia. spiral rubber lagged drive pulley with 3 7/16" shaft.
- i. 24" dia. head pulley with 2 15/16" shaft.
- j. 16" dia. self-cleaning winged tail pulley with 2 15/16" shaft.
- k. 8" dia. head and drive bend pulleys with 1 7/16" shaft.
- l. 16" dia. snum pulley with 2 15/16" shaft
- m. "Goodyear" pylon 210 belt with 1/8 x 1/32 covers and flexco lacing.

- n. Heavy duty self-aligning ball bearing pillow block terminals
- o. Welded tubular undercarriage with structural tubing and diagonal bracing for fixed incline of 18°.
- p. Pivoting wheel assembly with heavy duty truck rims and (4) new 7.50 x 20 10 ply tires (non-powered)
- q. Conveyor capacity of 525 TPH for coal 6" dia. or less.
- r. Conveyor shipped in 20' side truss sections with all necessary joint frames, diagonals and high strength bolts included for field assembly.

SHUTTLE CAR

One (1) National Mine Service TorKar Type 48-S18-36A1
designed to operate on 250 Volt DC Power.

Standard Features:

Single motor--mine duty 43 HP, DC
Torque Converter
Four-wheel drive
Four-wheel steer Orbitrol
Interchangeable wheel units
Zoned and piped out lubrication
Hydraulic brakes
Automatic cable reel hydraulically operated
Three-speed, forward and reverse transmissison
Standard or opposite standard controls
Conveyor speed, fast discharge with 15:1 Conveyor Drive
providing discharge rate of 120 FPM or slower discharge of
25:1 at 72 FPM.
Conveyor chain 3.075" pitch, 90,000# Tensile Strength
Flights--removable without separation of chain
Sealed Beam headlights

Permissible plate
Color--high visibility yellow
Auxiliary Lock-Up
Low Gear Starting

General Specifications:

Loaded height	36-1/16"
Height at loading end	17-5/16"
Overall length	25' 10-1/4"
Overall width	118"
Body width	114"
Conveyor width	61"
Capacity water level	175 cu. ft
with sideboards to 6"	226 cu. ft.
Clearance under frame	8-1/2"
Clearance under boom	
Lowered	13-3/4"
Raised	41-1/8"
Boom extension	49"
Wheel base	7'10"
Turning radius	
Min. outside	21'4"
Min. inside	8'9"
Tire size	10.00 x 20

Weight - Approx. 25,500 pounds

Tram speed

Low 1.90 MPH

Second 3.00 MPH

High 4.00 MPH

Optional Features:

Fire Suppression System

500 ft. of 2/0 2 Conductor Type "G" Trailing Cable

APPENDIX L
WATER ANALYSES
TABLE 1

Date Sampled 8/17/71

Determination	Point A	Sample Location Point B	Point C
M.O. Alkalinity (CaCO ₃)	68	48	--
Total Acidity (CaCO ₃)	12	24	--
Chloride (Cl)	1.49	1.56	--
Sp. Conductance (25°C) μ mhos/cm ²	149	134	--
pH (units)	7.7	7.2	--
Calcium (Ca)	27.2	19.2	--
Magnesium (Mg)	9.6	13.4	--
Hardness Total (CaCO ₃)	108	104	--
Sulfate (SO ₄)	47.0	53.8	--
Iron Total (Fe)	0.70	1.25	--
Aluminum Total (Al)	0.32	1.02	--
Manganese (Mn)	0.52	0.30	--

All results reported as parts per million (ppm) unless otherwise noted.

Point A - above Demonstration Mine Site
Point B - below Demonstration Mine Site
Point C - drainage from valley before entering creek

TABLE 2

WATER ANALYSES

Date Sampled 9/15/71

Determination	Sample Location	
	Point A	Point B
M.O. Alkalinity (CaCO ₃)	54	52
Total Acidity (CaCO ₃)	10	10
Chloride (Cl)	1.87	1.84
Sp. Conductance (25°C) μ mho/cm ²	220	200
pH (units)	7.0	7.2
Calcium (Ca)	27	27
Magnesium (Mg)	19	16
Hardness Total (CaCO ₃)	145	133
Sulfate (SO ₄)	74	67
Iron Total (Fe)	5.0	3.9
Aluminum Total (Al)	5.9	4.1
Manganese (Mn)	0.57	0.50
		Point C
		50
		4.0
		7.88
		220
		7.5
		23
		16
		123
		85
		6.1
		10
		0.42

All results reported as parts per million (ppm) unless otherwise noted.

Point A - above Demonstration Mine Site

Point B - below Demonstration Mine Site

Point C - drainage from valley before entering creek

TABLE 3

WATER ANALYSES

Date Sampled 11/10/71

Determination	Sample Location		
	Point A	Point B	Point C
M.O. Alkalinity (CaCO ₃)	75	60	52
Total Acidity (CaCO ₃)	14	20	8
pH (units)	7.1	6.8	7.3
Hardness Total (CaCO ₃)	180	170	128
Sulfate (SO ₄)	64.2	58.2	67.5
Iron Total (Fe)	1.3	4.6	2.3
Total Matter	251	373	305
Suspended Matter	31	161	105
Dissolved Matter	220	212	200
Aluminum Total (Al)	1.2	5.0	3.0
Manganese (Mn)	0.55	0.39	0.53

All results reported as parts per million (ppm) unless otherwise noted.

Point A - above Demonstration Mine Site

Point B - below Demonstration Mine Site

Point C - drainage from valley before entering creek

TABLE 4

WATER ANALYSES

Date Sampled 12/15/71

Determination	Point A	Sample Location Point B	Point C
		*	*
M.O. Alkalinity (CaCO ₃)	40	48	42
Total Acidity (CaCO ₃)	10	14	8
pH (units)	6.8	7.3	7.4
Hardness Total (CaCO ₃)	72	120	88
Sulfate (SO ₄)	31.9	27.2	50.6
Iron Total (Fe)	0.96	55	21
Total Matter	145	2,640	1,020
Suspended Matter	11	2,519	841
Dissolved Matter	134	121	179
Aluminum Total (Al)	0.4	63.5	30.0
Manganese (Mn)	0.46	1.6	0.88

All results reported as parts per million (ppm) unless otherwise noted.

*Sample - muddy

Point A - above Demonstration Mine Site
 Point B - below Demonstration Mine Site
 Point C - drainage from valley before entering creek

TABLE 5

WATER ANALYSES

Date Sampled 3/16/72

Determination	Point A	Sample Location Point B	Point C
M.O. Alkalinity (CaCO ₃)	26	23	24
Total Acidity (CaCO ₃)	3	4	2
pH (units)	7.25	7.0	7.2
Hardness Total (CaCO ₃)	61	65	73
Sulfate (SO ₄)	33	39.8	44.6
Iron Total (Fe)	1.4	1.9	2.3
Total Matter	128	153	213
Suspended Matter	11	26	59
Dissolved Matter	117	127	154
Aluminum Total (Al)	2.4	3.7	4.9
Manganese (Mn)	0.28	0.16	0.22

All results reported as parts per million (ppm) unless otherwise noted.

Point A - above Demonstration Mine Site

Point B - below Demonstration Mine Site

Point C - drainage from valley before entering creek

TABLE 6

WATER ANALYSES

Date Sampled 5/31/72

Determination	Sample Location		
	Point A	Point B	Point C
M.O. Alkalinity (CaCO ₃)	44	38	40
Total Acidity (CaCO ₃)	6	10	6
pH (units)	6.7	7.0	7.3
Hardness Total (CaCO ₃)	72	68	88
Sulfate (SO ₄)	42.2	43.9	64.3
Iron Total (Fe)	0.33	0.29	2.0
Total Matter	144	49	320
Suspended Matter	4	20	98
Dissolved Matter	140	29	220
Aluminum Total (Al)	<0.1	<0.1	4.4
Manganese (Mn)	0.08	0.13	0.39

All results reported as parts per million (ppm) unless otherwise noted.

Point A - above Demonstration Mine Site

Point B - below Demonstration Mine Site

Point C - drainage from valley before entering creek

TABLE 7

WATER ANALYSES

Date Sampled 8/14/72

Determination	Sample Location	
	Point A	Point B
M.O. Alkalinity (CaCO ₃)	54	56.0
Total Acidity (CaCO ₃)	3.6	3.6
pH (units)	7.1	7.7
Hardness Total (CaCO ₃)	110	108
Sulfate (SO ₄)	47.9	37.72
Iron Total (Fe)	0.87	0.65
Total Matter	189	163
Suspended Matter	23	19
Dissolved Matter	166	144
Aluminum Total (Al)	0.91	0.60
Manganese (Mn)	0.12	0.07
		Point C
		44.0
		3.6
		7.2
		124
		86.21
		3.0
		356
		139
		217
		6.0
		0.34

All results reported as parts per million (ppm) unless otherwise noted.

Point A - above Demonstration Mine Site

Point B - below Demonstration Mine Site

Point C - drainage from valley before entering creek

APPENDIX M
PROJECT DELAYS

The Phase II program was scheduled to be completed in eighteen months. Several unavoidable delays necessitated the re-budgeting of the project funds without requiring any additional funds and the granting of a twelve month extension. The project called for testing the life support system in the mine for six months. Additional delays caused by in-mine problems limited the actual test period to six weeks.

Underground Power Center

The delivery of the underground mine power center to operate the mining equipment was originally scheduled for sixteen weeks. However, due to back orders at the manufacturer's plant, delivery was changed to forty weeks. At the end of this time, it was found that additional modifications to the unit would have to be made in order to comply with the 1969 Federal Coal Mine Health and Safety Act. This caused an additional six week delay.

Life Support Systems

Initial delivery of the components for the life support system was scheduled for four months after the receipt of the purchase order. During the initial testing, several problems developed with the chiller and rebreather requiring a major redesign of the chiller and several modifications to the rebreather. These caused a six months delay in the delivery of this equipment.

Contract Negotiations

The life support system components were delivered just prior to the six weeks work stoppage caused by contract negotiations between the United Mine Workers of America and the Coal Operators. The test engineers were permitted access to the project office. However, little could be accomplished as work had progressed to the point where United Mine Workers personnel were required to adapt the life support system components to the mining equipment. No UMW personnel had been assigned to the project prior to the work stoppage as the work stoppage was anticipated.

Personnel Selection

Twenty-three applicants to work on the project were obtained from the adjacent mine labor force. From these, two men were selected for the project. Both men were members of the United Mine Workers of America and were subject to the controls of the contract in force at the time. These men were to be assigned to the project for its duration and afterward would return to their old jobs with no loss in benefits. The District 17 office of the United Mine Workers of America in Charleston, West Virginia, and the local union were approached to approve the use of union men on the project and agree that the men would return to their old jobs without loss of benefits when the project was complete. Permission was also requested to select the men by qualifications and not by seniority. Granting of this permission required three months, causing a like delay in the project.

Mining Equipment Approvals

The field modifications to the mining equipment destroyed the permissibility of each mining machine making it necessary to obtain special permission from the United States Bureau of Mines before taking the equipment underground.

Federal mine law states that any field changes made to any mining equipment should be accompanied by a field change report to the Bureau of Mines with a resulting inspection by Bureau personnel. The requirements of this project however were such that no amount of field changes could make the equipment permissible after the life support units had been attached to the machines since the life support units were not permissible. For this reason, there was no need to maintain the permissibility of the mining equipment.

After all of the equipment modifications were made, project personnel approached the U. S. Bureau of Mines at their Mount Hope, West Virginia, offices to request their permission to take the equipment underground for testing. Project personnel assured the Bureau that the mine was non-gassy and that all mining operations would be followed exactly as required by both Federal and State mining laws. These people were cooperative and stated they would review the request with their people before granting permission to take the equipment underground. Approximately two months were required for them to grant this permission, thereby delaying the project for this length of time.

Underground Test Section

Following the airflow change across the proposed test section, the change in air caused roof falls and rib rolls in the area. Additional time was required to clean up the area and make it safe for project personnel to work. In addition the need for extensive timbering, roof bolting, track construction, and ventilation controls consumed considerable time since only the two men assigned to the project were available to do the work.

APPENDIX N

COST SUMMARY TO OPERATE A
DEMONSTRATION MINE FOR 48 MONTHS

Capital Cost

Blanketing Gas Systems	\$1,154,500
Additional Mining Equipment	251,500
Life Support Systems	360,260
Additional Facilities	<u>123,000</u>
	\$1,889,260

Miscellaneous Operating Supplies \$276,100

Operating Labor \$2,839,120

Total \$3,115,220

Total Cost to Operate a
Demonstration Mine for 48 months \$5,004,480

Annual Operating Cost
Labor and Operating Supplies $3,115,220/4 = \$ 778,805$

CAPITAL COSTS
GAS BLANKETING SYSTEMS

<u>Item</u>	<u>Cost</u>
I) Water System	\$102,805
II) Gas System	222,040
III) Equipment Building	24,150
IV) Mine Ventilation Shaft	26,490
V) Refuge Station	5,650
VI) Equipment and Personnel	
Locks	22,425
VII) Office and Equipment	
Test Building	43,920
VIII) Coal Handling Facilities	44,860
IX) Instrumentation	154,700
x) Electrical	<u>148,435</u>
	\$795,475
15% Contingency	119,325
10% Contractor's O & P	<u>91,480</u>
	\$1,006,230
Engineering	<u>148,220</u>
GRAND TOTAL	\$1,154,500

CAPITAL COSTS
ADDITIONAL MINING EQUIPMENT

<u>No.</u>	<u>Item</u>	<u>Cost</u>
1	Coal Drill	From Phase II
1	Roof Drill	From Phase II
1	Cutting Machine	From Phase II
1	Loading Machine	From Phase II
1	Shuttle Car	From Phase II
1	Shuttle Car	\$50,000
2	Battery Tractors @ \$20,000	40,000
3	Supply Trailers @ \$1,500	4,500
4	Battery Chargers @ \$2,000	8,000
2	Boss Cars @ \$4,500	9,000
1	Personnel Car	12,000
1	Belt Feeder	35,000
1	36" Belt Conveyor 1000'	50,000
500'	44,000 Volt Cable	3,000
4 sets	Batteries	20,000
	Spares	<u>20,000</u>
		\$251,500

CAPITAL COSTS
LIFE SUPPORT SYSTEMS

<u>No.</u>	<u>Item</u>	<u>Cost</u>
16	Rebreathers and Chillers @ \$12,000	\$192,000
12	Suits @ \$2,000	24,000
36	Coveralls @ \$10.00	360
36	Stretch Garments @ \$15.00	540
36	Underwear @ \$10.00	360
16	Emergency Rebreathers @ \$400.00	6,400
3	Resuscitators @ \$700.00	2,100
20	Miner's lamps and chargers @ \$80.00	1,600
12	Radios and chargers @ \$1,000	12,000
1	Transmitter with repeater	12,000
1800'	Antenna Cable	1,300
16	Hearing Aids @ \$350.00	5,600
	Spares and repairs	<u>100,000</u>
		\$360,260

CAPITAL COSTS
ADDITIONAL FACILITIES

Site Preparation	\$25,000
Relocate Sub-station	5,500
Relocate Transmitter	1,500
New Office Building	65,000
Storage Shed	15,000
Power Line to Site	5,000
Water Line to Site	<u>6,000</u>
	\$123,000

OPERATING COSTS
MISCELLANEOUS SUPPLIES

Supplies -	
Baralyme	\$31,000
Purafil	15,500
Oxygen	8,000
Roof Bolts, Powder, etc.	35,000
Miscellaneous Tools	10,000
LP Gas	50,000
Power	30,000
Miscellaneous, photographs, analyses, etc., and Travel	<u>96,600</u>
	\$276,100

OPERATING LABOR

Mining Personnel	\$1,935,120
Administrative and Consulting	<u>904,000</u>
	\$2,839,120

APPENDIX O
SUPPLIERS OF COMMUNICATIONS SYSTEMS

1. MSA Research Corporation of Evans City, Pennsylvania
2. Arrowhead Products Division
3. Federal-Mogul Corporation, Los Alamitos, California
4. Motorola Communications & Electronics, Incorporated,
Parma, Ohio
5. Radioear, Incorporated, of Pittsburgh, Pennsylvania